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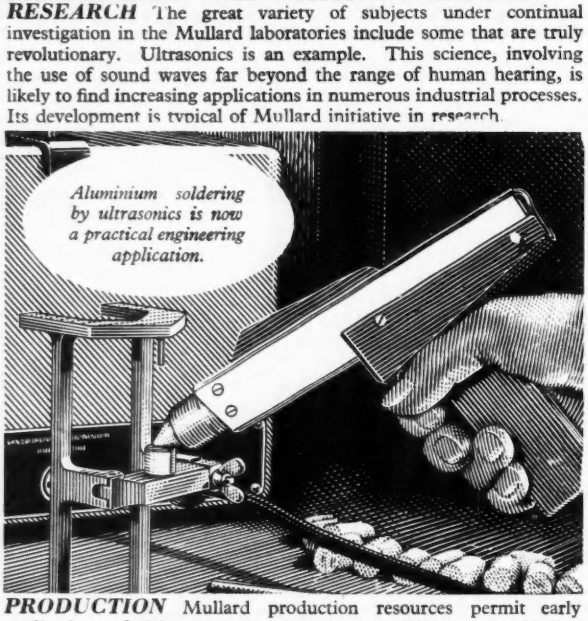

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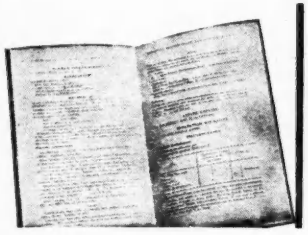

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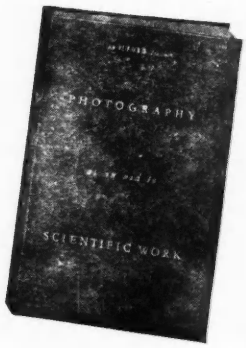

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DISCOVERY

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The Progress of Science

Uranium Rush, 1952

In 1945 when an international gathering of scientists met together to discuss the then novel atom bomb, Sir George Thomson pointed out the dangers of a uranium race, that would make the rush for oil look childish. But neither he nor any of the other scientists present could have imagined the scene at Uranium City, near Lake Athabasca in Saskatchewan, Canada in 1952. Nothing like it has been seen since the Klondike Gold Rush in 1896–7. Oddly enough there is a connexion, for the lake near the site of the present rush takes its name from the Athabascan Indians who also had a northern stronghold in the Yukon and the Klondike area. Nor was the Atom Age rush much different, except in scale and the equipment carried. Geiger counters replaced spades, picks, dynamite, mortars and pestles, and pans.

The rush started on August 4th this year, when the three-year concession of the El Dorado Mining Company expired, and the Government of Saskatchewan declared some 300 square miles of land open for public property. Licences to prospect cost five dollars each, and claims up to 1500 square feet were allowed. Each claim had to be staked in the traditional and now internationally recognised manner, with one post at each corner at least four feet high, and one of them bearing hour, date, name and licence number. A time limit of fifteen days was set for registering claims; although some slight extension was allowed for more distant areas. The rush brought some two-thousand-odd prospectors to the scene, and made the fortunes of the storekeepers and taxi drivers of the small town now styled Uranium City. Over one thousand claims were registered, but few of these are likely to prove worth mining.

One difficulty is the limited range of sensitivity of the Geiger counter which makes it difficult to assess the uranium oxide content of the pitchblende at a distance of more than a few feet. Only mining or drilling will yield real information. A few will probably be lucky, for the richest pitchblende deposits so far discovered in Canada (deposits which are spread throughout a huge arc of northern Canada, from Labrador in the west to Cape Bathurst in the east) have been found in this region.

Already the El Dorado Mining Company and several other companies have mines working in the district, and plan to build a large processing station. Although the yield from these mines has so far proved disappointingly low, this is partly due to inefficient processing. There can be no question that the Canadian uranium deposits are some of the world's largest and of considerable importance.

By law all uranium mined in Canada must be sold to the Government, who in turn sell much of it to the United States (where it must in any case be sent for final purification since Canada has no plant to do this).

Few of the prospectors are likely to be able to afford to work their own claims or even undertake an adequate assay. This will have to be done by the mining companies already established. It is possible that some high-yielding seams may be discovered as a result of the 1952 Uranium Rush, but this return to the nineties is surely a very odd and somewhat lunatic way of achieving something which could have been better done by means of an efficient Government survey.

X-rays and Pig Breeding

In collaboration with the School of Agriculture, the Low Temperature Research Station, D.S.I.R., at Cambridge has been using X-rays to assess the quality of pigs. The technique can be of great value to pig breeders in producing better pigs. It provides information about the animal which could previously be obtained only by killing. It could also be used in show judging.

A most important characteristic of a pig is its length. The longer the animal the better, for the proportion of lean meat to fat is improved and there are more valuable cuts. In normal pigs, the number of ribs can vary from 13 to 17 and in general the more ribs the longer the pig. Pig breeders should, therefore, aim at developing a pig with a longer backbone and more ribs than is usual in Great Britain. Up to now, British pigs have been comparatively short.

The length of a pig depends on the number of vertebrae it has. This varies in individual pigs. To breed longer pigs means selecting those with the most vertebrae. So far, selecting pigs for breeding has had to be done entirely by

eye. This is a skill which has reached a high degree of development. It cannot be relied on, however, to give definite information about the number of vertebrae and the number of ribs. It may also give a wrong estimation of the proportion of fat to lean meat. The only certain method of finding out about these points has been to kill the animal and look at the carcass.

The new technique enables litter testing to be done quite simply. Small pigs are easy to handle and can be stretched out under the X-ray camera. The number of vertebrae can be counted on the screen or film, and pigs for breeding separated from the rest. Larger pigs are more difficult to handle unless they are familiar with the person using the apparatus. This may limit the usefulness of the X-ray technique for judging pigs at shows. At the Low Temperature Station, however, X-ray films have been used to show even the difference between layers of fat in adult pigs, information which is important to research.

The equipment used is commercially produced in this country. It is portable and packs into a box which can be carried by one man. It plugs into the ordinary electricity supply.

Into the Spider's Web

Most people who are familiar with the silk spun by the silkworm (*Bombyx mori*) have never examined spider's silk closely. It is finer and chemically different,* and doesn't stand up well to spinning. Individual threads vary in thickness from one hundredth of a millimetre to as fine as one ten thousandth of a millimetre, according to the species of spider concerned and the glands from which it is produced. (There are several different types of silk glands in the typical spider species.) The average diameter of the silk thread is from three to seven thousandths of a millimetre. The specific gravity of spider's silk is 1·28 as compared with from 1·34 to 1·367 for true silk, and a thread from the spider called *Nephila* long enough to go round the world would weigh less than six ounces. The extreme fineness of the thread is brought home by the calculation—made by Réaumur in 1710—that 27,000 spiders would be needed to produce a pound of silk. Réaumur pointed out, moreover, that the spiders would all have to be kept and fed separately because of their cannibalistic tendency. Although the Chinese Emperor was so interested by the title of Réaumur's paper that he requested its translation into Manchu—it thus became the first scientific paper from Europe to appear in the Chinese language—he can only have gained reassurance in the commercial superiority of the silkworm's product.

An attempt to use spider's silk commercially was made in Madagascar in the nineteenth century, using the Great Orb-weaver, *Nephila madagascarensis*, but even with the aid of cheap local labour the cost proved prohibitive. Today its sole commercial use is in the manufacture of micrometer eyepieces and similar optical instruments, where threads of the utmost fineness are needed.

* Chemically, spider's silk differs from that of the silkworm in being a homogeneous protein fibroin with little sericin in its composition. Ordinary silk consists of an inner core of protein fibroin with a surrounding layer of sericin. The fibroins in the two cases are allied, but are not identical.

Mr. Theodore H. Savory's remarkable book entitled *The Spider's Web* (Frederick Warne & Co. Ltd., London, 1952, 12*s.* 6*d.*), the latest volume of the Wayside and Woodland Series, which contains most of the facts quoted above, is however mainly concerned with the spiders' actual craftsmanship and the mechanics of web-spinning. But no relevant introductory knowledge is neglected. It is important to realise that "the two most striking physical properties of spider silk are its elasticity and its strength". Its actual strength can be measured in terms of its Breaking Stress—the ratio between the maximum load and the cross-sectional area of the thread. Comparative figures are, for *Bombyx* (silkworm) silk 62, for iron 39, and for spider's silk a range between 48·7 and 54·6 to 142 kilograms per square millimetre. Its elasticity too is remarkably high; the most elastic spider's silk is found in the viscid web-threads, which are the sticky threads forming part of the web on which the prey is captured.

Probably few people realise that many species of spider do not spin webs. But in Britain the web-spinners are well represented among the 570 British species, of which only about eighty are not web-spinners. The silk of the non-web-spinners goes into such things as egg cocoons, linings to burrows and trap-door hinges. But it is the web-spinners which are the acme of Araneid life.

Only two other creatures in the animal kingdom (not one as Mr. Savory claims) build snares. They are the larva of the Caddis *Hydropsyche* and the Ant Lion, but the spider's snare is certainly the most remarkable. The development of the web-spinning habit is one of the mysteries of evolution. As Savory says, "The start must be closely related to the origin of the secretion silk, and silk is a converted excretion, an example of what would today be called salvage." Thus the beginnings can be traced in the tracking drag line which by accident became both a burrow lining and a crude snare as each sortie to capture prey increased the mass of silken thread. The British spider known as *Segestria florentina* produces a primitive web of just this type in holes and crevices of walls, rushing out from its silken tube with "guyed bell-mouth" whenever an insect alights on the fringe.

The common house spiders of the genus *Cinflio* produce a similar web, the cobweb, only here there is a larger outer sheet. Another member of the house spider's family *Agelena labyrinthica* spins webs of this sort on the ground in June and July when it is young. But when fully grown its webs are found on bushes (in particular gorse bushes), and have additional threads above the main sheet, although these are not needed for support. From this, says Savory, "there may be said to arise the type of web which has no tube, nor hiding-place, but consists only of the tangle of upper threads and the sheet or hammock". This is the typical web of the commonest group of all British spiders, the Linyphiidae. And so indeed, one can trace possible lines of evolution onwards to the hammock web with added strands below, and after that the big gap between all other webs and the orb-web with its complex spirals and radii. Some idea of its superior complexity may be gained from the fact that Mr. Savory takes sixty pages of clear concise writing to describe its making and the problems connected with it, as against a mere sixteen for all other forms of web together.

The spinnarets of the spider are two, four, six, or eight in

number. There are usually six and they are found on the fourth and fifth somites, near the middle of the abdomen. Each conical spinnaret has either 60 to 100 small tubes or 'spools' on the spinning surface, each producing a fine thread, or up to five larger tubes called 'spigots' which produce thicker threads. In many spiders the inner spinnarets of the first two pairs are united to form a special large spinning plate called the cribellum. This produces the flocculent silk net with which the prey is tied up after being caught in the web; but although present in many orb-weavers, it is not used in the manufacture of the web itself. The silk used for this purpose comes from the ordinary spools and spigots.

The first action in the making of these webs is the fixing of the bridge thread from which the structure hangs. This involves bridging a gap, and to do this the spider often releases a gossamer thread of fine silk, allowing it to fly in the breeze until caught on some object. After testing it, the spider then climbs along this thread, rolling it up in front of it while replacing it behind with a strong, thicker thread. More rarely it climbs down trailing a thread attached at the starting-point, walks along the ground, and then up a neighbouring support, pulling it tight and fixing it at the appropriate level.

With the bridge thread (AB) established, a complicated routine commences. The spider returns along the thread, paying out a second thread (indicated by broken line below AB) which it attaches at the end A. It then comes back to a point (X) near the middle, attaches a new thread to this second one and drops down to a lower point (Z) where this third thread X′Z is attached. The tension of this thread pulls the second one downwards, causing threads two and three to form a Y-shaped frame. The meeting-point of the three arms of this frame is the future hub of the web.

A somewhat similar process now follows. Starting from the hub X′, the spider crawls up one of the two upper arms of the Y, carrying a new thread which it attaches at a point (C), about half-way up. It then returns, and about a third of the way down, at D, attaches a new thread to the one just laid, and carries this round past the hub and up the other upper arm of the Y to a point (E) about half-way up. Here it attaches the thread whose tension pulls the equivalent thread on the other side of the Y outwards, forming a second wider-angled Y—this is the thread ED′CX′.

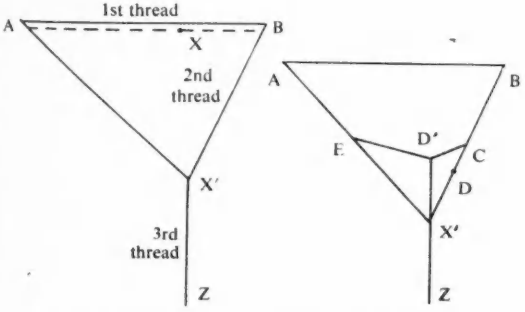

FIG. 1.—The first two stages in the spinning of an orb-web. It is important to realise that under the weight of the spider the thread AXB sags downwards to take up the shape AX′B.

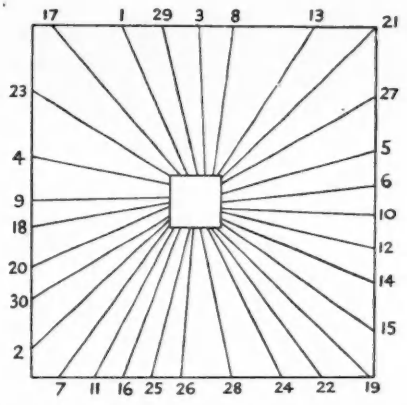

FIG. 2.—This diagram gives an idea of the sequence in which a typical orb-spinner adds the radii to its web.

This process is then repeated between AZ and BZ, thus completing the central reinforced frame around which the rest of the web is constructed.

The radii are next completed. The spider turns clockwise and counter-clockwise back and forth in the hub with front legs stretched out as if testing the angles of the spokes, then runs down one and along the frame, fixing its dragline to the chosen spot and returning to the hub, thus completing a new spoke. No order is followed in the placing of the radii but the process continues until the angles are filled in to its satisfaction.

The hub has now become a central platform, the radii being often joined as if by accident with short threads. It is now strengthened deliberately in the same way by means of a series of close spiral turns of thread. While this is done the earlier strands may be cut and removed. Then follows the stretching out of the curling web with dry silk. This involves a widening spiral journey from near the strengthened zone outwards round and round the radii. But a space is always left between the start of this spiral and the inner strengthened zone.

The spiral stops only when the spider cannot stretch between two radii. The spider now rests. Then after a while, it returns slowly and carefully, replacing the dry silk with the prey-catching silk wetted with the viscid solutions of the Aggregate glands attached to the two hind pairs of spinnarets. This careful work occupies more time than any other part of the web-making. Only the laying of the signal thread from the web to the retreat now remains, and all is ready.

In the vertical orb-webs the spider awaits its prey lying in its retreat, only resting at the hub at night-time, but in the horizontal orb-webs the spider may have no retreat and keeps constant watch at the hub.

How this complicated behaviour could have evolved from the simple web-building of other spiders remains unanswered. It is odd that despite his interest in the mental ability of trap-door spiders, and his correspondence with Moggeridge, Darwin never seems to have thought of this problem. In such webs as these, the angles between the upper shorter radii are wider, and those between the longer lower radii are narrower. Mathematical examination shows an

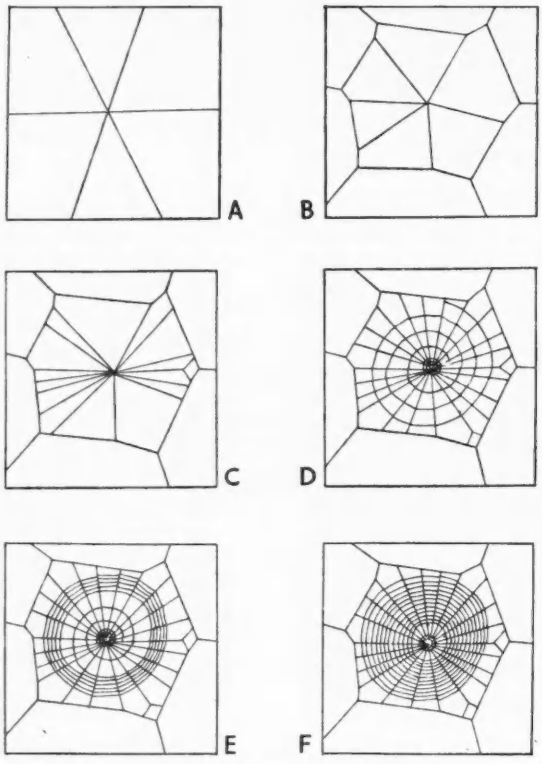

FIG. 3.—A simplified diagram indicating the successive stages in the spinning of an orb-web.

exactly similar relationship between the angles subtended by the spider's two pairs of hind legs and those subtended by the two pairs of front legs. If the first pair of legs are missing there are fewer radii in the lower part of the web and larger angles between them as this relationship would lead one to suspect. But such studies, although they demonstrate relationships, explain little.

That tension is the vital factor in spider behaviour is shown by laboratory experiments in which frames attached to adjustable supports were squeezed out of shape, causing altering tensions in the threads of the web. Even a two-degree change markedly altered the spider's behaviour and with a five-degree change in the angles of the supports, the spider only found its way home in three out of 24 trials.

The whole of spider behaviour would seem to be dominated by this extreme sensitivity to touch and physical tensions. Mr. Savory's book is a remarkably lucid and concise exposition of a fascinating subject. It should do much to encourage further study in what is clearly a most important and too neglected field of animal behaviour.

(Figs. 2 and 3 come from T. H. Savory's book mentioned above, and Fig. 1 is based on another of his diagrams.)

Transmitting Electric Power across the Channel

A NOTE in our monthly notebook of December 1950 mentioned the world's longest under-sea power cable, which when completed will supply the island of Gotland, 62¼ miles off the east coast of Sweden, with hydro-electric power from the mainland.

Another newsworthy scheme for carrying electric power across a sea barrier is the plan to take a 132,000-volt cable across the English Channel and so link the electricity grid of Britain with that of France. Power engineers have been speculating on this idea for a long time, but now a scheme has been worked out in great detail. The projected cross-Channel link has been judged to be 'technically feasible', and experts say that it could be constructed within three or four years. But political decisions have to be taken before the signal to go ahead can be given to the engineers, and it would therefore be rash to suggest that the construction work on the projected cable is likely to start in the near future.

What would be the advantages of having a cross-Channel link? One is the advantage which comes with any extension of a network of interconnecting electric power stations. The operating efficiency of the larger network is higher than that of the smaller one, for the reason that a larger *proportion* of generating units are in operation at any one time. Think of the days before there were electricity grids: a town would have, say, two generators, one of which would be producing current while the other remained idle, being kept as a stand-by in case of need. That means that the town's electric generating plant is run at only 50% of its capacity. (For Britain as a whole before the grid was organised, 70% of the total generating capacity was in effect 'spare'.) Now consider a grid system; in such a network of interconnected generating units, any one unit can act as a stand-by for any other unit, with the result that only a small proportion of generating equipment in the grid need be kept idle. The higher efficiency possible with the grid is appreciated when one considers the cost of generating electricity before and after Britain's grid came into being; thus in 1926, a pre-grid year, the average cost of generating a unit of electricity was 0·4*d.* as compared with only 0·19*d.* in 1936.

Another advantage which would result from having a cross-Channel link is this. Britain's grid is short of generating capacity in the winter, just when France with its large number of hydro-electric units has power to spare. In the summer Britain's steam-powered generators could help France out when the flow of the rivers is reduced and her hydro-electric generators are therefore handicapped. The link would help both countries to balance the demand for electric power against the supply.

It is estimated that the cost of the cable would be about £4½ million. The construction and laying of the cable present plenty of technical problems, and it is reckoned that development work required to solve these will cost an extra £250,000.

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Sir William Ramsay (1852–1916)

F. M. BEATTY, M.A.

THERE are few achievements in the history of chemistry which appear now so remarkable and so satisfyingly complete as those of Sir William Ramsay, who was born a century ago—on October 2, 1852. As a discoverer of chemical elements he occupies a unique position for, while Sir Humphry Davy has surpassed him in the number of these discoveries, Ramsay alone can be said to have introduced a complete new family into the assembly of the elements—the inert or 'rare' group of gases. As heir to the long line of British pneumatic chemists, he was destined to give forth the last and most glorious fruits of that great school. Moreover, the virtual completion of the Periodic Table made possible through these discoveries and their connexion with radioactive phenomena were important in the development of the theory of radioactivity and in the interpretation of the periodic law in the more fundamental terms of the nuclear atom.

Ramsay believed he had chemistry in his blood, and the scientific attainments of several of his ancestors certainly tempt one to imagine that the ability was inherited. His grandfather, who came of a family of dyers, had distinguished himself in dyestuffs research and was founder and first president of the Chemical Society of Glasgow. His father, a man of wide scientific interests, was an engineer who had taken part in the development of the Scottish railways and his uncle became Director-General of the Geological Survey. His mother's family included some distinguished medical men. So Ramsay was brought up in a scientific atmosphere, and this probably played the biggest part in determining how his great natural abilities were to be engaged.

Matriculating at 14, Ramsay followed an Arts course at the University of Glasgow for the next two and a half years. Private study had made him familiar with French and German, and had already revealed the exceptional ability for languages which was later to be of great value to him. His enthusiasm for chemistry was first aroused through reading the chemistry textbook by Thomas Graham, the Scottish chemist whose name is permanently attached to the famous law of the diffusion of gases, and who was the first president of the Chemical Society of London.

Ramsay's first experience with practical chemistry was gained in the small laboratory he set up at home with parental encouragement. His practical knowledge was much enlarged during the eighteen months he spent in the laboratory of the Glasgow City Analyst where he worked after leaving the university and where he gained a good grounding in analytical chemistry. During that period he also found time to attend chemistry lectures at the university.

Ramsay was now firmly decided on a chemistry career but, during the next ten years, events combined on many occasions to frustrate his opportunities for research. Thus one valuable experience was denied him when the outbreak of the Franco-Prussian war stopped him going to Heidelberg to work under Bunsen as he had planned. In the following year, after a period spent working in Lord Kelvin's laboratory and attending his lectures, he succeeded

in getting to Tübingen to work under Fittig, in whose laboratory he carried out some research on platinum-ammonium compounds and on the toluic acids. (For his investigations of the latter compounds he gained his Ph.D.) But when he returned to Scotland in 1872 and was appointed assistant to the Professor of Technical Chemistry at the Royal Technical College, Glasgow (as it is now known), he soon realised that he would have to put aside his hopes of continuing the researches he had begun at Tübingen. However, two years later he became an assistant at Glasgow University and there he collaborated in research with Sir James Dobbie; among other things, they prepared pyridine from quinine and cinchonine, alkaloids whose connexion with pyridine Ramsay was the first to point out. Here, too, he became his own guinea-pig in order to observe the physiological action of certain anaesthetics. During this period he became associated with J. B. Hannay, a physical chemist of high abilities, to whose influence can be traced Ramsay's first deviation from organic chemistry into the field in which he was destined to make his greatest achievements.

Then in 1880 Ramsay was appointed to the chair of chemistry at Bristol University College (forerunner of Bristol University) and in the following year became Principal of that college. He was a great success in that position, and extending his influence to a still wider field he played a leading part in the movement which secured Government support for education in the University Colleges. Although his own research activities were somewhat restricted by his administrative duties, a notable research school was built up at Bristol, and with his chief collaborator, Sydney Young, Ramsay carried out a classical series of experiments on liquid-vapour systems and their thermodynamical relationships. In creating special apparatus for these and other physico-chemical researches Ramsay became an expert glass-blower, and this skill was to stand him in good stead later.

We have now taken Ramsay's life to the point where he left Bristol to become Professor of Chemistry at University College, London, in 1887; here he was following in the footsteps of Thomas Graham, who occupied that post from 1837 to 1855. It was here that Ramsay carried out his greatest work, and here he remained until his retirement in 1912.

For the first few years the reorganisation of the department took up much of his time, although he continued some of the work begun at Bristol on liquid-vapour systems and published several important papers on molecular surface energy. It was not, indeed, until 1894 that he launched forth on the research which led to the discovery of the whole family of the inert gases—argon, helium, krypton, xenon and neon.

Background to the Discoveries

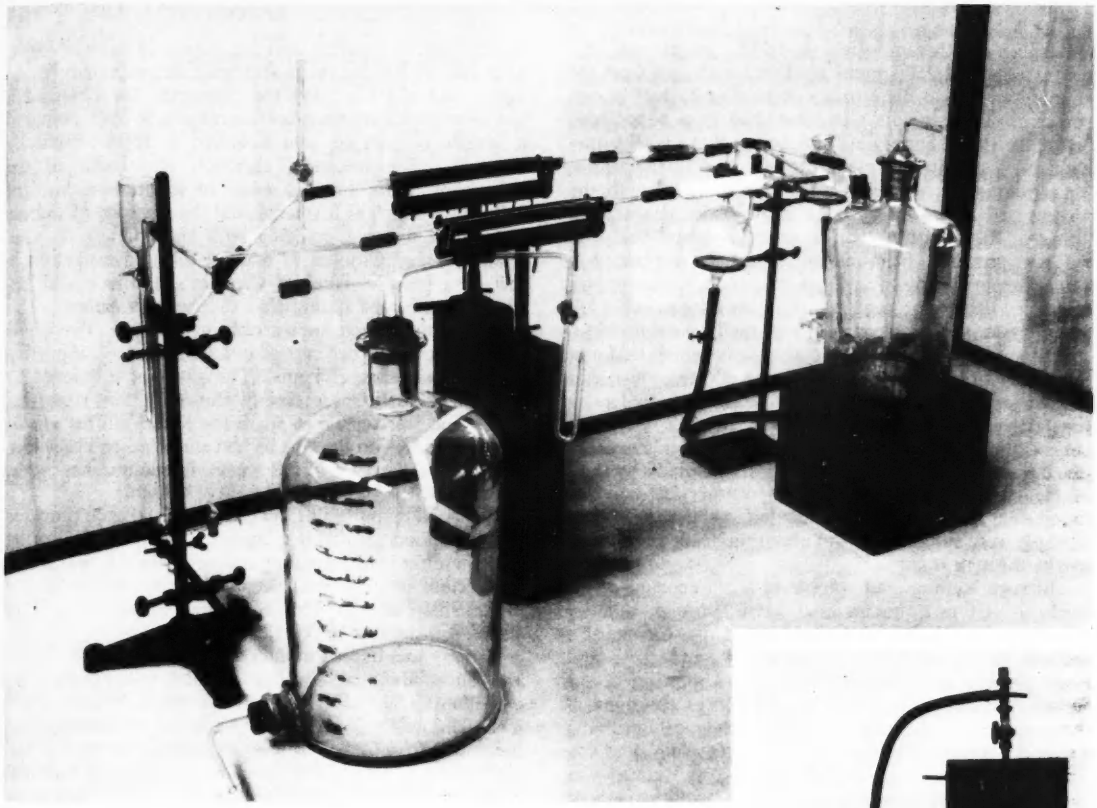
To appreciate his achievements here one needs to take a short look at the position in the 1880s of the branches of physics and chemistry on which these discoveries were built. Theories of atomic structure were then relatively primitive, including neither the concept of the electron (which was discovered in 1897) nor of the nuclear atom (first suggested in 1911). Nevertheless, atomic theory, current at the time Ramsay started his investigations which led to the discovery of argon, went quite a long way beyond the hypothesis William Prout put forward in 1815, according to which the hydrogen atom was the fundamental particle from which all elements were constructed, so that the atomic weight of elements should be integral multiples of the atomic weight of hydrogen. During Ramsay's time Mendeléeff's periodic law and the significant arrangement of elements in the Periodic Table gained acceptance and greatly influenced scientific thought. Many chemists of the time found understandable difficulty in accepting Prout's hypothesis in which the hydrogen atom figured as the fundamental particle of atomic structure, since many atomic weights were clearly not whole numbers; it was not until isotopes had been discovered that the true position became clear.

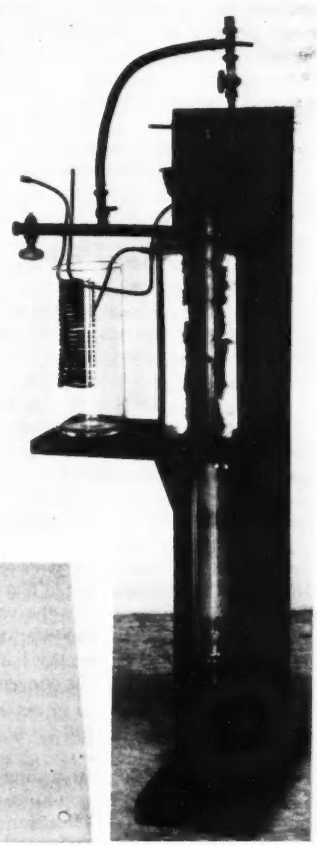
The technique of spectrum analysis, upon which Ramsay relied so much in his researches, had been initiated by Bunsen in Germany and had found its chief British exponent in Sir William Crookes who in 1861 discovered the element thallium by this means. It had many triumphs in the 1860s and '70s, one of the most remarkable being Lockyer's discovery in 1868 of the new gas, helium, in the sun's spectrum.

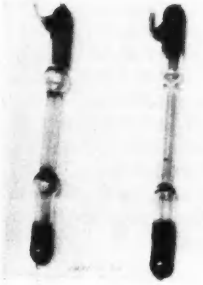
Also essential to his work were the techniques of low-temperature physics. The conditions under which the so-called 'permanent' gases could be liquefied had become apparent through Andrews's classical work on carbon dioxide in 1863, by which date critical phenomena were fully understood. Faraday had liquefied chlorine in 1823, but the modern era of low-temperature research begins with the liquefaction of carbon dioxide and oxygen in 1877 by Cailletet and Pictet working independently. By 1887 Wroblewski and Olszewski in Poland, also using Pictet's cascade process, had succeeded in liquefying all the gases then known except hydrogen. In 1894 Olszewski succeeded in liquefying hydrogen also, but not in sufficient quantity to determine its physical properties; Olszewski's liquid hydrogen boiled away in a few minutes. Ramsay's later work could not have been successful without the preparation of liquefied gases in a form stable enough for further work to be carried out on them. This became possible partly through Dewar's invention of the vacuum flask in 1872, and also through the exploitation of the Joule-Thomson effect (cooling a gas by expansion through a porous plug), which was applied for the first time in 1895 by Linde in Germany and by Dewar and Hampson in this country.

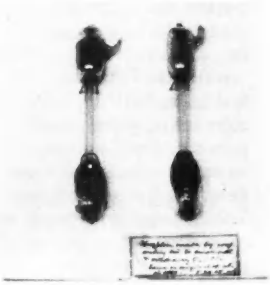
The Discovery of Argon

We now come to the first of that chain of discoveries which will carry Ramsay's name down to posterity as, in Donnan's words, "the crowning glory of British pneumatic chemistry". Lord Rayleigh had in 1882 begun to redetermine with great accuracy the densities of the principal gases for the purpose of testing Prout's hypothesis. In 1892 Ramsay wrote to Rayleigh expressing interest in the work he was carrying out on nitrogen. Rayleigh had been puzzled by the difference in density between atmospheric nitrogen and nitrogen obtained from chemical sources such as ammonium nitrate; the difference was extremely small,









These three photographs show apparatus used by Ramsay which is now on show in the Science Museum in the special exhibition arranged there in connexion with his centenary.

FIG. 1 (*top*).—Ramsay's apparatus for producing argon in quantity (1894).

FIG. 2 (*right*).—The hydrogen liquefaction apparatus designed by Travers and used in the isolation of neon in 1900.

FIG. 3 (*below*).—Spectrum tubes used by Ramsay in the analysis of the rare gases. *Left:* helium tubes. *Centre:* krypton tubes. *Right:* helium from radon.

atmospheric nitrogen weighing 1·2572 grams per litre compared with 1·2505 grams per litre for the gas from the ammonium salt—a discrepancy amounting to half of one per cent. These results were presented in a paper read before the Royal Society in 1894, and in that year Ramsay obtained Rayleigh's permission to try to find the reason for the anomaly. Ramsay believed this was due to the presence of a heavier gaseous impurity in atmospheric nitrogen; Rayleigh took the opposite view, and held that the gas prepared from chemical sources contained a lighter impurity until Ramsay's preliminary experiments convinced him to the contrary. Ramsay now gave his full attention to the problem and, repeatedly passing atmospheric nitrogen over heated magnesium (which he knew from some of his earlier work to be an effective absorbent of nitrogen), he obtained a gaseous residue whose density progressively approached the value of 20. Rayleigh, almost simultaneously, succeeded in isolating this residual gas, but in "miserably small quantities"; he used a method of Henry Cavendish who, over a century before, had found that a small residue was left when oxygen and nitrogen were eliminated from atmospheric air by passing sparks through it.

Although Ramsay had completed a full account of his work by the time he received from Rayleigh a letter reporting the results he had obtained by Cavendish's method they agreed to publish jointly, and their first announcement was made at the Oxford meeting of the British Association in September, 1894. The chairman of the session, in consideration of the gas's chemical inactivity, christened it *argon* after the Greek word for 'idle', and this was indeed to prove a well-chosen name, as Ramsay was to find after a long series of unsuccessful attempts to induce it to enter into chemical combination.

The determination of the properties of the new gas likewise involved prolonged research although it soon became apparent from specific heat determinations that the gas must be monatomic, and that an atomic weight of 40 was therefore implied.

It is scarcely to be wondered at that the announcement of the finding of this new gas should have been greeted with scepticism; some critics maintained that argon must be a mixture of two or more gases, to which some support appeared to be lent by Sir William Crookes's spectroscopic examination which showed, under different conditions of discharge, two totally distinct spectra. This, and the less supportable suggestion that argon might be triatomic nitrogen, meant that it was some time before argon was finally accepted by chemists as a new element.

The behaviour of the gas at low temperatures was investigated by Olszewski in Poland, as it was not until 1899 that University College acquired a liquid-air plant. The Polish work supported the view that it was a simple substance and not a mixture or unstable compound. Meanwhile, however, Ramsay had succeeded in isolating a second gas which it will be convenient to discuss now.

Helium's Discovery

This next discovery was a direct consequence of Ramsay's interest in possible non-atmospheric sources of argon, and when he heard that Hillebrand of the U.S. Geological Survey had obtained an inert gas, supposed to be nitrogen, after heating the rare mineral cleveite, he suspected that he might find argon among the products. He obtained a specimen of this uranium-bearing mineral in 1895, prepared a sample of the gas and observed it spectroscopically (Fig. 3). The spectrum, although containing all the prominent argon lines, showed in addition a brilliant yellow line which at first suggested the presence of sodium but which did not coincide with the sodium D_3 line. Ramsay asked Crookes to make a fuller investigation: a few days later he received Crookes's dramatic and unexpected telegram stating that the gas was *helium* which had previously been known only in the sun. The whole investigation had been carried out within a week of hearing of Hillebrand's experiments. The advantages enjoyed by academic scientists are clearly shown in this story, for Hillebrand was unable to spare the time from his official duties to follow up the clue he had stumbled on and which was to put Ramsay, with his greater freedom of action, on the track which led to the isolation of helium.

The small quantities of the gas which could be prepared by this method delayed the determination of the properties of helium but it was not long before its density was found to be close to 2; as the specific heats again indicated a monatomic gas, this gave an atomic weight of 4. Like argon, it proved to be remarkably inert.

Ramsay was happiest when working with some reliable and congenial colleague, and immediately after his discovery of helium he invited Dr. Morris Travers to join him in investigating the properties of the new gas; this was perhaps the most fruitful of all his scientific associations and Dr. Travers, who recently celebrated his eightieth birthday, has given us an enlightening series of accounts describing Ramsay's working methods and personality, the latest having appeared this year (*Endeavour*, July 1952). Dr. Norman Collie, who later became professor of organic chemistry at University College, also joined Ramsay in this work.

For the next two years Ramsay's further researches on the two gases he had discovered were mainly concerned with fruitless attempts to combine argon and helium with other substances, and in looking for other sources from which they might be prepared.

Ramsay's Search for Other Inert Gases

Although the discoveries of argon and helium sprang direct from observations by other scientists, his later discoveries were wholly his own. He predicted them and, with his colleagues, drove ahead until he achieved them.

After the discovery of argon, Ramsay's loyalty to the periodic law made it important for him to find a place for this element of atomic weight nearly 40 within the framework of the Periodic Table (Fig. 4). Here he met with his first setback. If this were a diatomic gas it would have an atomic weight near to 20 and would fit in very conveniently between fluorine and sodium: but the specific heats indicated a monatomic gas. With the discovery of helium, however, for which a place could readily be found in the Table, Ramsay made up his mind that these two elements must be members of the missing eighth group of elements, and that the anomalous position of argon (for the periodic

Group VII	*New Group VIII*	*Group I*
H 1	He 4·2	Li 6·9
F 19	?	Na 23
Cl 35·5	A 39·2	K 39·1
Br 79·9	?	Rb 85·5
I 126·9	?	Cs 132·0
? 169·0	?	? 170
? 219·0	?	? 225

FIG. 4.—A section of the Periodic Table as it appeared to Ramsay in 1895 after his discoveries of argon and helium. Only the elements in the two groups adjacent to the supposed new group of inert gases are shown.

law required a regular increase in atomic weights from left to right of the Table) must be accepted. At this time only one other similar anomaly was known to occur throughout the whole Periodic Table.

Having made this decision as to argon's position in the Periodic Table, Ramsay started searching for elements to fill the gaps in Fig. 4; his conviction that these gaps represented gaseous elements was so strong, especially in regard to the undiscovered gas of atomic weight 20 between helium and argon, that when he made this view public at the British Association meeting at Toronto in 1897 he was able to give an accurate prediction of many of the properties of the missing elements. He now consciously set himself to search for these unknown elements.

The Discovery of Krypton, Neon and Xenon

But his quest for further members of the group had already begun in 1895 when, with Dr. Travers and others, he was busily examining gases from a great variety of sources—from minerals and meteorites and from hot springs which he visited in Iceland and the Pyrénées. The principal object of these researches was the discovery of alternative sources of helium and argon which were indeed found in many cases either separately or together; but the hope of finding fresh elements of the new family of gases was an added stimulus.

As no progress was made in this last direction it was decided at the end of 1897 that the gases of the atmosphere should be more closely examined. However, owing to the inertness of the rare gases there was no possibility of separating them by chemical means, and attempts by Ramsay and Collie to effect a separation by the process of diffusion had failed. It was therefore necessary to look for new physical methods and, as it was virtually certain that all these gases would become liquid at different temperatures, it was clear that if the necessary low temperatures could be attained, any new gases mixed in the air could be separated from one another by fractional distillation. In this process the constituents of a mixture of liquids are separated by collecting the portions, or fractions, of the vapour given off at suitably chosen temperatures. In general, the most volatile fractions are given off by the constituents with the lowest boiling-points.

In 1898 a substantial quantity of liquid air was obtained from Dr. Hampson of the British Oxygen Company and allowed to boil away until a few cubic centimetres were left in the vessel. The remaining liquid, now richer in the less volatile gases such as argon and oxygen, was purified (in gaseous form) to remove the oxygen and any remaining traces of nitrogen. Spectroscopic examination of the gas so obtained showed that it contained an element distinct from argon or helium. This new element was called *krypton*, or the 'hidden' gas. Some time elapsed before it could be isolated from the argon with which it was mixed, and its properties determined, but it quickly became clear that krypton was heavier than argon and hence it could not be the 'unknown gas' of atomic weight 20 for which Ramsay was searching.

With Dewar at the Royal Institution also in the field the work was now pushed forward with great speed. A large quantity of atmospheric 'argon', previously prepared, was now liquefied using liquid air boiling under reduced pressure as a coolant (Fig. 1). On removing the coolant, the first quantities of the gas which boiled off were collected and the procedure repeated with this portion. Finally, after purification, the ultimate portion was introduced into a vacuum tube which gave off a 'blaze of crimson light' that announced the discovery of the 'unknown gas' *neon*. In quick succession came the discovery of *xenon* (or 'the stranger'), which was detected in the argon-krypton mixtures by the distinctive blue line in its spectrum. The important role of spectroscopist in this work was played by E. C. C. Baly.

But it was two years before these three new gases, each of which had only been detected as the predominant part of a mixture of gases, could be isolated and determinations made of their physical properties such as density, atomic weight, specific heats and boiling-point. Refractive index and density measurements showed that the proportion of the required gas in the various mixtures could now be increased only with extreme slowness by the fractionation process, and that little progress could be expected until more abundant supplies of liquid air became available. This problem was solved in 1899 when University College was presented with a liquid-air apparatus which made it possible for xenon, the heaviest of the five gases and the one with the highest boiling-point, to be isolated in nearly pure form. An atomic weight determination was then made which came close to the now accepted value of 131. Krypton, intermediate in density between the argon and xenon with which it was mixed, proved harder to separate, but it too was isolated in 1899; the value found for its atomic weight was also slightly below the now accepted value of 84.

The isolation of neon was more difficult and, as it became clear that to obtain this gas in a pure state fractionation of the gas mixtures would have to be carried out at even lower temperatures, its isolation involved as an incidental stage the liquefaction of hydrogen. This must itself rank as a major and original achievement; for although Olszewski

had carried out his short-lived liquefaction of hydrogen in 1894, new techniques had now to be developed which would enable comparatively large quantities of the liquid to be prepared and used over an extended period of time. Sir James Dewar had indeed liquefied hydrogen in bulk in 1895, but the description of his apparatus was not then available to Dr. Travers who was responsible for this part of the research (Fig. 2). By a modification of the Linde-Hampson process, however, 60 c.c. of hydrogen were obtained in 1900 and used to cool the helium-neon-argon mixture (the presence of helium had not been suspected in the original mixtures). This treatment solidified the argon and neon, and pure neon was then obtained by pumping it away from the less volatile argon and refractionating. The atomic weight of neon (the 'new' gas) was found to be nearly 20, the value predicted five years previously by Ramsay through his imaginative faith in the periodic law.

Our admiration at the manner in which Ramsay conceived, approached and overcame the problem of conjuring these gases from the air changes to amazement when we consider the minute proportions in which they exist in the atmosphere. Thus argon is present by volume in one part in a hundred, but krypton exists to the extent of one part in a million while only one part in twelve million consists of xenon. This means that if all the xenon in the atmosphere were spread uniformly over the surface of the earth it would form a layer only $\frac{1}{8^{\frac{1}{6}}}$-inch thick.

Work on Radon

With the completion of these unsurpassed researches on the five new gases Ramsay went for four months to India to advise on the setting up of a teaching and research establishment, which later took form as the Indian Institute of Science at Bangalore and of which his colleague Dr. Travers in 1903 became the first director. But this did not represent the end of his contribution to science. A further rich chapter of achievement lay ahead.

The discovery of radium by the Curies and of the thorium 'emanation' by Rutherford in 1902 placed Ramsay in a position of special importance. There were three reasons for this. Firstly, the radioactive emanations from thorium, actinium and radium were found to be gases chemically inert like argon. Secondly, helium had been found, as we have seen, in certain minerals which contained elements belonging to the radioactive series. And thirdly, Ramsay had revolutionised the techniques for manipulating extremely small quantities of gases. It was therefore natural that at the beginning of 1903 Dr. Soddy, Rutherford's collaborator at Montreal, should come to London to work under Ramsay on these emanations. Using a microvacuum tube made by Ramsay himself (Fig. 3) an investigation of the spectrum given by the radium emanation (now called radon) was attempted. Although this was not observed it was noticed that, after the tube had been run for some time, the spectrum of helium began to appear. It was at once apparent that this was a discovery of the highest importance, being the first demonstration ever made of one element in process of transmutation into another, and it formed a striking confirmation of the Rutherford-Soddy theory of 1902 which had postulated that radioactive change involved atomic disintegration. Moreover the proof that helium was a product of such a change suggested to Rutherford that the α-particles emitted by radioactive substances might consist of helium nuclei, a supposition which he was to confirm later in 1906.

Ramsay was naturally interested to know how radon fitted into the Periodic scheme and to determine its properties. It must have been clear from the outset that the experimental difficulties involved in this project, in which he was associated with Professor Whytlaw Gray, would be formidable and that all Ramsay's ingenuity and superlative skill would have to be brought into play. In the first place the quantity of radium available was sufficient to provide less than one-tenth of a cubic millimetre of radon; secondly, radon was radioactive, half of the amount disintegrating in less than four days. However, by developing a special microbalance of high sensitivity it became possible in 1910 to weigh less than a pin-head's volume of the gas and to determine the atomic weight of radon as 223, close to the value indicated by Rutherford's theory. The melting, boiling and critical points were determined the following year. With this work on the member of the argon group of highest atomic weight Ramsay "set the crown on the research begun seventeen years previously with the isolation of argon".

The radon researches stimulated Ramsay's imagination in other directions and we find him actively engaged in the early stages of the therapeutic use of radon against cancer; while in 1912, after some experiments in which he believed he had caused atomic disintegration by the action of radon on certain salts, he was speculating "whether, if elements are capable of disintegration, the world may not have at its disposal a hitherto unsuspected source of energy".

Of his work outside the field he made his own it must suffice to say that he left his mark in every branch of chemical science. His retirement in 1912 from the chair of chemistry at University College, where he was succeeded by Professor F. G. Donnan, must end our account of his main scientific achievements.

Ramsay's Character

Ramsay was not a man to be deterred by the temporary frustrations and failures of his efforts, for of these troubles he had his full share; he had the resources to rise above his difficulties. In his *Gases of the Atmosphere*, the first edition of which was published after the discovery of argon and helium, there is an indication that Ramsay regarded his search for the unknown gases partly in a spiritual sense; it may be that here he found the deepest sources of encouragement which enabled him to bring the work to a complete and triumphant conclusion.

Those who knew him speak of his most attractive personality, full of charm and good humour and able to disarm the most serious rival. He formed lasting friendships with his scientific colleagues at home and abroad. We have already mentioned his flair for languages. In this connexion it is worth recalling that he was an ardent advocate of the idea of establishing a universal language. His laboratory in London was usually full of visitors and, as he disliked secrecy, they could rely on seeing whatever they wished. Distinguished foreign chemists would be

invited to dine at his house; among these was Mendeléeff, whom Ramsay first met in 1884 and who no doubt did much to inspire his great faith in the periodic law. He made frequent visits abroad, including in his itinerary such research centres as Berlin, where he met Emil Fischer, Kohlrausch and van't Hoff; Leipzig, where his great friend Ostwald reigned; Paris and Leyden. In the New World he visited the United States, Canada and Brazil.

He received recognition of his scientific internationalism in full measure. A recipient of the 'Légion d'Honneur', of the 'Pour le Mérite', and of innumerable honorary degrees, he was made a foreign member of national scientific academies and learned societies throughout the world. In Britain he was elected to the Fellowship of the Royal Society in 1902; while in 1904 he became the first Briton to receive the Nobel Prize for chemistry, the same year in which Lord Rayleigh received the prize for physics. He was Foreign Secretary of the Chemical Society for five years, and later its President.

Mention should be made of his great interest in scientific education, of his abilities as a teacher and of the stimulation of his presence in the laboratory. Among the pupils and research workers who came under his guidance were an exceptional number of future professors of chemistry; of foreign workers who came to his laboratory one of the most important was Otto Hahn, who discovered radiothorium while working in the College in 1904 and who was later to share in the crucial experiment which proved the possibility of uranium fission.

Ramsay was nearly sixty when he retired from University College but he continued to carry out research, first in his London house and later in his new home near High Wycombe, to which he moved just before the 1914–18 war broke out. To the exclusion of further academic research he now devoted himself to matters concerned with the war until, at the beginning of 1916, he became seriously ill and died in July of that year.

No memorial to him can equal that which he himself built and made us aware of in the air around us. But it would have pleased him that shortly after his death, at University College with which he had been associated for over a quarter of a century, a fund should have been started in his memory to promote chemical teaching and research. From this arose the Ramsay Memorial Laboratory of Chemical Engineering at University College (completed in 1931) and the Ramsay Memorial Fellowships whose international character Ramsay would certainly have approved.

Consequences of Ramsay's Work

We have already spoken of the important part Ramsay's discoveries played in the theory of radioactivity and in directing attention again to the atomic theory and to the periodic law with the result that within a decade the underlying physical principles began to be brought to light.

The inertness of each of these gases, which can be attributed to the completion of the outermost shell of electrons surrounding the atom, has given them a special importance in certain applications. Thus argon is now the standard filling for metallic-filament electric lamps; if they were not so scarce krypton and xenon would be even more suitable. Argon and helium are both extensively used as protective atmospheres for high-speed electric arc welding of certain high-nickel alloys used in gas turbines and also of aluminium structures; they are thus invaluable to the aircraft industry and are also used to fill atomic radiation or Geiger counters.

Helium has had a useful but now somewhat restricted career as a filling for airships and balloons in preference to the highly inflammable hydrogen; it was with this object in view that Ramsay, during the First World War, carried out analyses of some American natural gases containing helium. The industrial production of helium was first carried out in this country in 1904 by Thos. Tyrer and Co. under Ramsay's direction, Ceylon monazite sand, the rare-earth mineral from which thorium is obtained, being used as a source. The production of helium in certain radioactive minerals provides a geological tool of some value; the helium is usually retained in the mineral and in such cases its amount provides a direct measure of the age of the mineral under examination.

The use of neon (and other gases of the family) in discharge tubes continues to provide splendid advertisements in most towns and cities to Ramsay's imagination and persistence, in spite of competition from mercury-vapour lamps with fluorescent coatings; the fog-penetrating power of these tubes also makes them of value in lighthouses and on aerodromes.

For the theoretical physicist the discovery of helium has presented some problems of great interest. In low-temperature physics the existence of helium in two distinctive liquid forms—helium I and helium II—and the superfluidity and other remarkable properties of helium II provide major unsolved theoretical problems. While the possibility that stellar energy may be maintained by the transmutation of hydrogen into helium is strongly supported by the presence of helium in stellar spectra.

Thus research workers in the pure and applied sciences as well as those concerned with maintaining the freedom and international position of science will have reason to keep Ramsay in memory.

Wren's monument still stands before us to justify his epitaph; but Ramsay's will always surround us in the very air we breathe.

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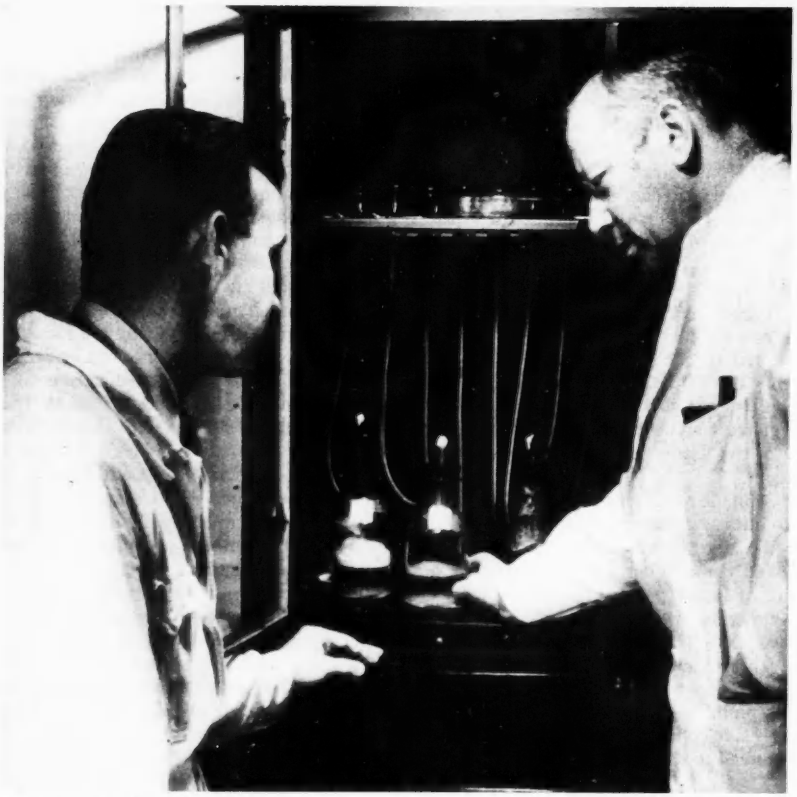
(The picture of Ramsay on p. 307 is reproduced by permission of Prof. Morris W. Travers, F.R.S., and University College, London.)



Vaccination to immunise farm animals against foot-and-mouth disease was first tried about a hundred years ago. The original vaccination technique used virus material taken from the blisters occurring on the tongues of infected animals; injected into other animals this crude vaccine was followed by mild symptoms of the disease from which they recovered, afterwards showing increased resistance against foot-and-mouth. Large-scale production of vaccines was developed by scientists, but this still depended on propagation of the virus in living animals. Recently Dr. H. S. Frenkel (*seen on the right*) of the State Veterinary Research Laboratories in Amsterdam perfected a process in which virus for vaccines is grown on tissue obtained from slaughter-houses. This revolutionary new technique is shown in pictures, on pages 316 and 317, and is described in words by Sir Thomas Dalling, who was Chief Veterinary Officer of Britain's Ministry of Agriculture before he joined F.A.O.

Foot-and-Mouth Vaccines

SIR THOMAS DALLING, D.Sc., F.R.C.V.S.

PUBLIC attention has again been directed towards the control of foot-and-mouth disease because of the recent extensive outbreaks in European countries and the somewhat widespread occurrence of the disease in Great Britain during the past nine months. The use of suitable vaccines for preventive purposes must be giving some concern to many people, even in this country. It has been generally agreed that, wherever possible, vaccination should not be part of a control policy and Great Britain is to be congratulated on the firm stand taken to adhere to the 'stamping out' or the popularly termed 'slaughter' policy. It is not the purpose of this article to discuss matters of policy or reasons why this country continues its present system of control. Excellent and valid reasons could be brought forward in full justification of the method.

In many parts of the world, however, the use of vaccines by a controlled scheme of vaccination is not only advisable but essential and the expectation is that the incidence of the injection will be so reduced that it may be possible, at some future date, to introduce a general system of 'stamping out'.

Vaccination against foot-and-mouth disease is no new venture. It has been practised for many years in many countries. Until recently, much of the vaccine in use has been prepared by the Schmidt-Waldmann method, which necessitates the use of living cattle. All vaccines for foot-and-mouth disease control have, as their base, the virus against which the vaccine is to be used. In order to procure a sufficient supply of virus for vaccine production, the virus has to be 'cultivated' or 'grown' so that large amounts will

be available. With many disease-producing micro-organisms this is a simple matter, for cultivation and therefore increase in numbers are readily achieved by the growing of the respective micro-organisms on artificial media, often specially selected for the respective microbe. With viruses, the position is not so simple, although research workers are gradually perfecting methods of artificial cultivation. It seems that one of the important conditions for the cultivation of viruses is the presence of living animal tissue. So-called 'tissue-culture' has long been known and practised. The introduction of the 'egg' technique in cultivating viruses marked an important development in the study of these minute objects—a method in which the developing chick embryo and its various components are used. Viruses are sometimes differentiated by their action on such living tissue.

A common method for the cultivation of viruses was the introduction of the virus into the susceptible tissues of living animals. On some occasions the animal chosen was that in which the disease occurs naturally; on other occasions, a non-susceptible animal is selected and certain tissues are used, e.g. the nervous tissue, following the injection of this virus into the brain. Such 'discoveries' are continually being made and applied in the study of viruses as a whole.

In the Schmidt-Waldmann method of the propagation of the virus of foot-and-mouth disease for vaccine production, the tongue of living, susceptible cattle is used. Within a comparatively short time following the intra-dermal inoculation of the virus into the tongue, large amounts of virus are produced, as shown by the appearance of many vesicles on the tongue. The epithelium of the tongue, at this stage, is rich in virus.

Fig. 1 (overleaf) illustrates a tongue, following injection a few hours previously, in which there is evidence of extensive virus multiplication. Although it would appear that large quantities of virus must be present in this epithelium, the amount is, comparatively speaking, limited, with the result that the amount of vaccine that can be prepared from the virus obtained from the tongue of one animal is also limited. While virus so produced makes excellent vaccine, there are disadvantages in this method of virus production, one of which is cost. It has been estimated that vaccine prepared from virus produced by this method costs a minimum of about one U.S. dollar per cattle dose.

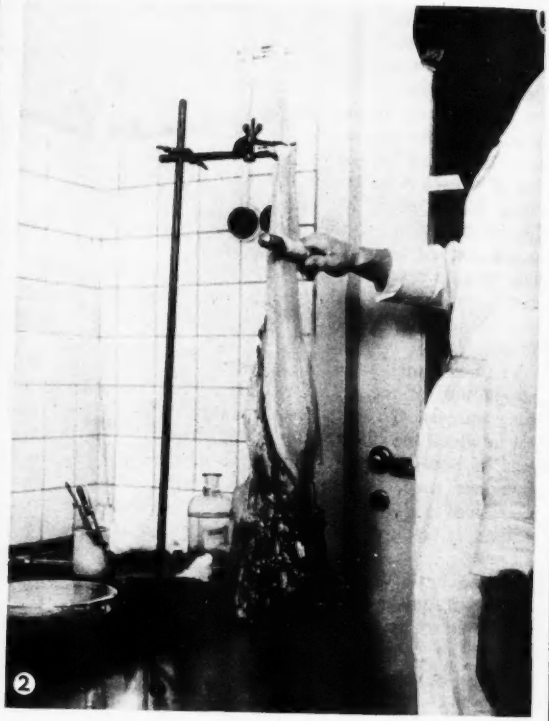
Research work on the cultivation of viruses is being carried out in many countries and the results of the work are being applied extensively. The virus of foot-and-mouth disease appears to have an affinity for epithelial tissue, especially that of the digestive tract. Experiments carried out over a number of years by Dr. Frenkel in his laboratory in Amsterdam showed that it was possible to produce rapid multiplication of the virus on the epithelial tongue tissue of cattle, removed from the recently killed healthy animal and used before it is actually 'dead'. By preserving the tongue epithelial tissue under conditions of cold, without freezing, there is evidence that it is serviceable for foot-and-mouth disease virus propagation for a few days. Dr. Frenkel has worked out special techniques for the removal of the epithelium from the tongues, its 'cleaning' and preparation for virus cultivation. This 'discovery' has resulted in a method for the preparation of virus in large quantities and obviates the need to use the living animal for virus production. Such artificially cultivated virus can be stored for long periods under suitable low-temperature conditions and may be used for vaccine production many months or even years after it has been grown. The treatment of the virus, whether naturally produced as in the Schmidt-Waldmann method or artificially produced as in the Frenkel method, for subsequent vaccine production, is essentially similar. Because there is no need to use living animals for the propagation of the virus, the cost of producing vaccine by the Frenkel method is greatly reduced.

Tests carried out in the field and in the laboratory show quite clearly that vaccine made by the Frenkel method sets up an immunity of at least the same order as does the Schmidt-Waldmann vaccine. The illustrations Figs. 2–7 portray some of the steps in the production of virus by the Frenkel method and the preparation of vaccine from it on a large scale.

It is now well recognised that certain types of foot-and-mouth disease virus can give rise to symptoms which appear to be exactly similar and which are recognised as clinical evidence of foot-and-mouth disease: and further, there is now some evidence that within the types themselves there may be a strain or sub-type variation, even from an antigenic or immunising point of view. There is no reason to suppose that the Frenkel method of virus cultivation does not apply equally to all the various strains or sub-types. It may be that some special encouragement has to be given to some special strain to develop the ability to grow under these artificial conditions and to acquire the capacity for rapid reproduction. These subjects, however, are matters of detail which can undoubtedly be resolved by the patient endeavours of the research worker.

The 'discovery' of Dr. Frenkel has opened up great possibilities in the preparation of foot-and-mouth disease virus on an extensive scale and, therefore, schemes for use of the vaccine over large parts of the world. The supply of satisfactory epithelium from the tongues of cattle for large-scale virus production may cause some little concern. It has been shown that, although the tongues of cattle which have already been immunised against the disease or which have recovered from a natural attack of the disease, have epithelium of some value for virus cultivation, much better results are obtained by using the epithelium of the tongues of highly susceptible animals. In countries in which vaccination is widely practised there might therefore be difficulty in procuring suitable epithelium. Already there is evidence from small-scale experiments that tongue epithelium from recently killed susceptible cattle can be transported under conditions which allow the retention of growth properties. Further experiments are about to be carried out on this subject, in which the conditions of transport over long distances will be studied, together with the economic aspects. There is no reason to suppose that transport difficulties will prove insurmountable.

In many countries lively interest is now being shown in the Frenkel method of vaccine production and there is much evidence that in the national and international schemes for the control of foot-and-mouth disease in which vaccine will certainly play a part in some countries, vaccine prepared from virus cultivated by the Frenkel method will be of great importance.



THE FRENKEL TECHNIQUE WHICH HAS REVOLUTIONISED VACCINE PRODUCTION

FIG. 1.—THE OLD METHOD of making foot-and-mouth vaccines—the Schmidt-Waldmann method—depended on the use of living animals. The vaccine material is collected from the tongues of cattle which have been infected with foot-and-mouth disease.

FIG. 2.—THE NEW METHOD perfected by Dr. Frenkel represents a real departure from the previous technique. It is based on the use of tongues from recently killed healthy cattle and does not involve living animals at all. The skin of the tongue is stripped off, and tissue scraped from the underside of that skin is used for growing the virus from which the vaccine is prepared.

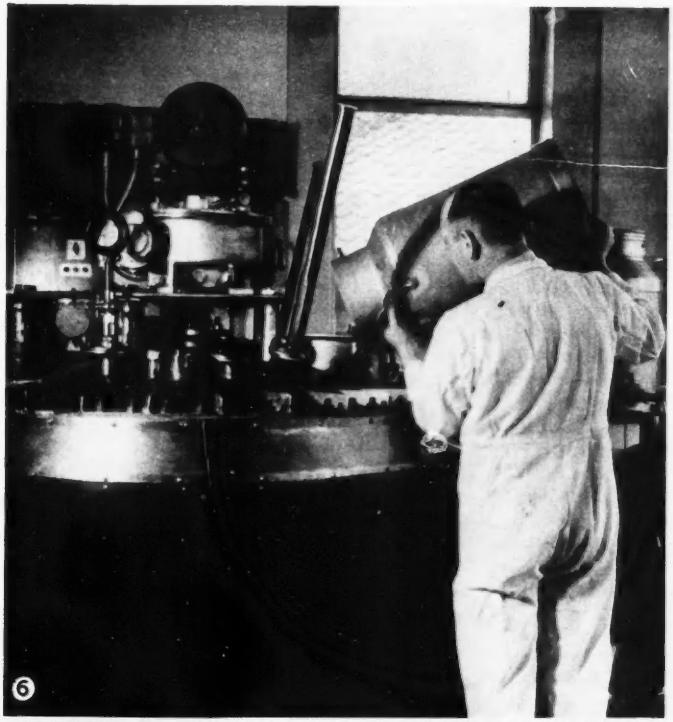
FIG. 3.—The tissue is put into a glass dish; penicillin and streptomycin are added to keep bacteria under control.

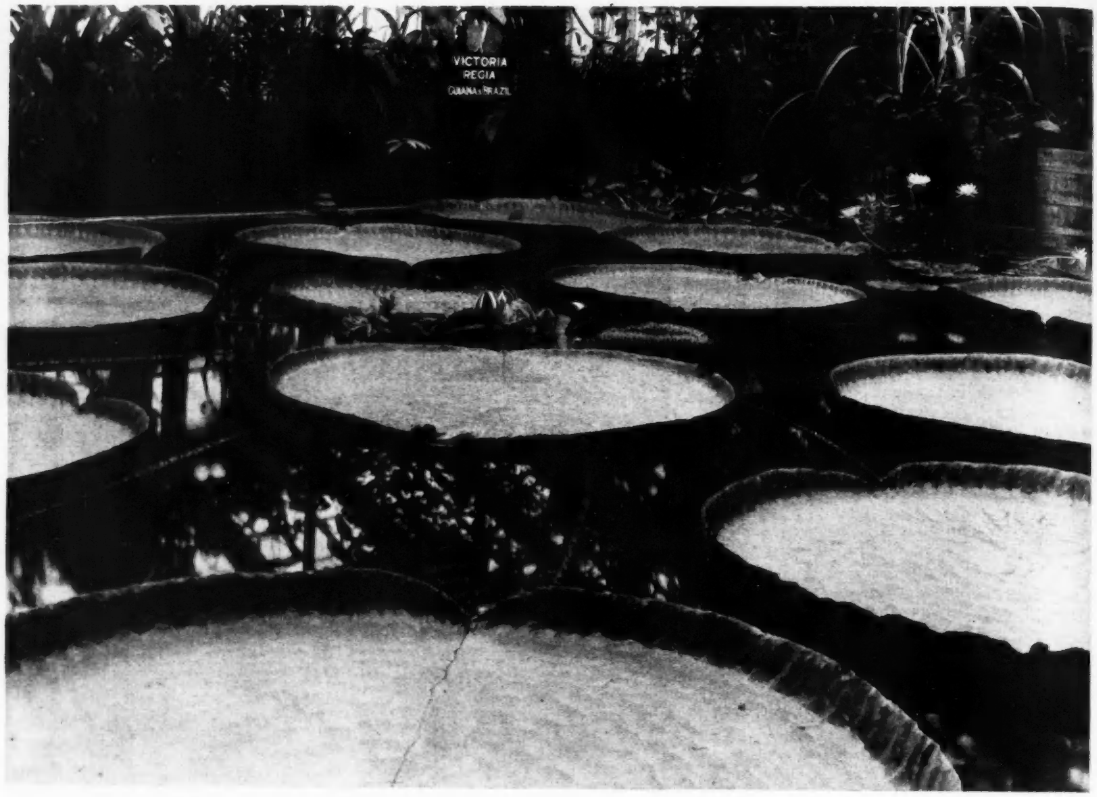
FIG. 4.—Virus is added to the tongue tissue by means of a pipette, and proceeds to multiply. (This incubation stage is carried out in big stainless steel vessels when the vaccine is being produced in large quantities.)

FIG. 5.—The tongue tissue now rich in virus is bulked and carefully strained; the liquor which filters through provides the vaccine material.

FIG. 6.—In this vessel, known as a 'stirring autoclave', formalin is added to the liquor. This chemical inactivates the virus to the extent that it causes no ill-effects when injected into cattle, but is still able to produce an immunising reaction in the animals.

FIG. 7.—In a room beneath the stirring autoclave, the vaccine is bottled under sterile conditions. The bottles are then capped, and are ready for dispatch to any part of the world. Vaccine prepared by the Frenkel method has been extensively tested and proves to give as good protection as vaccines prepared from virus from live cattle.





The great Amazon Water Lily, known to many as *Victoria regia* but properly called *Victoria amazonica*, is probably the most famous plant in Kew's huge collection. This is grown as an annual; seeds sown in January yield plants whose leaves (up to 6 ft. in diameter) cover its tank before late summer, when the flowers are produced.

The Royal Botanic Gardens, Kew

SIR EDWARD SALISBURY, F.R.S.

THE association of Kew with botanical science carries us back some four centuries, for the author of the first English herbal, William Turner, who has been called "The Father of English Botany", lived at Kew and had a garden there towards the middle of the sixteenth century; but it was the fact that Kew was a favourite place of residence of royalty that led to the establishment of the world's most famous garden in an area where the alluvial sandy soil provides conditions far from favourable for easy culture.

It was to Princess Augusta, mother of George III, that the botanical gardens, in the modern sense of that appellation, owe their establishment. There are, of course, older gardens such as those of Padua, Paris and Montpellier, but Princess Augusta was perhaps almost a pioneer in the concept of a botanical garden for the culture of collections of species grown for their intrinsic interest rather than because of their economic value in medicine or in horticulture. It was further evidence of her ability that she chose Lord Bute to assist her with advice, and William Aiton, the author of the *Hortus Kewensis*, to fill the post of head gardener. Moreover, it was the gifted Sir William Chambers whose help she enlisted to embellish the grounds with architectural features, of which the Orangery, built in 1761, and now serving as a museum, is justly regarded as a masterpiece of design. The garden established in 1759 was but nine acres in extent, yet when Princess Augusta died in 1772 it had already achieved a high international reputation. By 1779, when the *Hortus Kewensis* was published, there were some 5500 species in cultivation. Little could Princess Augusta have dreamed that two hundred years later nine times that number of living species would be maintained at Kew, and that from her small beginnings would have grown the mighty instrument for research of today. Before this was to come about, however, the gardens were to suffer from a period of neglect culminating nearly a century ago when, largely owing to the report of John Lindley, the first Professor of Botany at London University College, the gardens at Kew passed from private into public ownership.

In 1841, Sir William Hooker was brought from Glasgow and appointed the first Director of the Royal Botanic Gardens under the new régime, and he took immediate steps to provide the additional space for the living collections that was so greatly needed. Within five years of his appointment the area had grown almost to its present extent so that the original nine acres now formed but a small part of over two hundred and sixty, which was further augmented in 1897 by Queen Victoria's gift of the Queen's Cottage grounds—thirty-seven acres in extent—for maintenance in a semi-wild state.

With Sir William Hooker came also his extensive herbarium, but the Kew Herbarium, by far the largest and most important in the world because of its wealth of types, may be said to have originated with the gift of Dr. Bromfield's herbarium in 1854, and of the still more important herbarium of George Bentham in the same year, to house which the Queen granted the use of Hunter House. But this building has three times had to be enlarged, once in 1877, again in 1902, and yet again in 1932. Today these collections comprise between five and six million specimens, but what is far more important scientifically is that they contain over 200,000 types, using that term in the broad sense. The Bromfield and Bentham bequests also initiated the extensive taxonomic library now numbering some 50,000 volumes, in addition to which there are numerous pamphlets and separates besides a valuable collection of flower paintings.

The Library and the vast collection of dried and living plants comprise the essential tools for the study and identification of plants. These serve as the equipment and material for the resident scientific staff, for the taxonomists seconded for longer or shorter periods from the Dominions and Colonies, and for a succession of specialists from all parts of the world, who come to work in the Herbarium and avail themselves of the facilities which the gardens afford.

Essentially Kew aims at extensive collections covering the entire world's flora rather than intensive collections of particular groups. It is thus clear that the functions of Kew are fundamentally international and imperial rather than national, except in so far as the greater includes the less. This international aspect is witnessed not only by the diversity of races represented by those who come to carry out research within these walls, but also by the *Index Kewensis* and its quinquennial supplements, which are prepared in the Herbarium. This indispensable tool for taxonomists is an index to all the described species of flowering plants giving references to where the original descriptions can be found. Here, too, was prepared the famous *Genera Plantarum* of Bentham and Hooker as well as the great succession of Dominion and Colonial floras. Of such were Bentham's *Flora Australiensis* in seven volumes (1863–78); the monumental *Flora of British India* (1872–97) in seven volumes by Sir Joseph Hooker, consisting of over five thousand five hundred closely printed pages dealing with some fourteen thousand species; the *Flora of Tropical Africa* in ten volumes, in which Daniel Oliver took a leading part; the *Flora Capensis* in seven volumes; floras of New Zealand, Ceylon, Hong Kong, and most recently the *Flora of Tropical West Africa*, the last volume of which appeared in 1937.

Kew's Economic Importance

The Gardens contain four museums in which are extensive collections of economic products of plants, timbers, fibres, fruits and the like, which serve both for purposes of identification and research. Another department of the Garden organisation is the Jodrell Laboratory, where the anatomical characteristics of plants are studied. Thus the various departments serve to provide the means not only of pursuing original research but also of dealing with the endless succession of inquiries on all aspects of taxonomy. Accurate identification is the first essential to all exploitation and is fundamental, but hardly less important are the economic aspects investigated at Kew which have had far-reaching effects. Chief amongst these was the introduction of the Para rubber tree, *Hevea brasiliensis*, to the East, and the development of the Wardian case (a small portable greenhouse) at Kew—its effective utilisation for transport of live specimens was the means of initiating the plantation rubber and cinchona industries. So, too, the widespread culture of the pineapple was assisted by the distribution of the famous Smooth Cayenne or Kew Pine that still holds its place in the industry. In more recent years Kew has played an important part in the introduction of the Oil Palm (*Elaeis guineënsis*), the Queensland Nut (*Macadamia ternifolia*) and Tung Oil plants (*Aleurites*). It also acted as a quarantine station for the new types of banana prior to their dispersal to various parts of the Empire.

The living collections constitute a storehouse of research material for the professional botanist, the plant geneticist, the pharmacologist and many others. Living material, whether as plants, cuttings or seeds, is distributed on an exchange basis for purposes of research to other scientific institutions throughout the world; every post brings requests for such or inquiries that involve the utilisation of the collections either living or dead.

Kew Gardens, because they were well planned and laid out by men of taste as well as men of learning, is the 'Mecca' not only of the horticultural world, but of many others whose appreciation of plants is less sophisticated. Thus on a fine June day, no less than 70,000 persons may visit the gardens, but in recognising and welcoming the attractions that the gardens offer to the general public, it must be emphasised that the Royal Botanic Gardens is a scientific institution first and foremost, and its use as a place of recreation must be subordinate to this primary rôle, a fact which those who press for longer hours of opening of the houses and removal of restrictions on games, etc., are too apt to forget.

The wealth of experience gained by the culture of this vast diversity of species has been of inestimable value to the devotees of horticulture and has provided the basis of standard horticultural works. The famous *Dictionary of Gardening* was produced by George Nicholson who occupied the post of Curator from 1886 to 1901. This not only retains its position today but was the model for both French and American works of a similar character. The classic, *Trees and Shrubs Hardy in the British Isles*, was written by William Bean as the outcome of his training at Kew and his curatorship of the Arboretum. But botanists and horticulturists alike come to Kew to see species of the

genera in which they are interested growing either in the open or under glass. Altogether some 45,000 different kinds of plants are grown in the diverse conditions that the gardens offer. A large number to maintain, but, of course, a mere tithe of the entire flowering plant population of the world. Nevertheless, in the Palm House can be seen representatives of many species of Cycads, whilst the Orchid collection contains representatives of a large proportion of the genera in this, the largest family of flowering plants. The difficulty of maintaining so large a variety of species increases out of proportion to the augmentation in numbers, and in general the shorter the duration of life of species, the more labour and care is involved in their perpetuation. Thus trees and shrubs once established demand little care, but a large amount of space, and at Kew, as in other botanical gardens, limitations in the latter respect preclude the proper provision for succession. Annuals and biennials, on the other hand, while making smaller demands on space, place the greatest burden on labour through their repeated replacement. One of the problems that must be faced is the need for selection due to the limitation both of space and labour.

The arrangement of specimens in the past was a taxonomic one, members of the same family being grown in proximity to one another. This method of grouping has the great advantage of facilitating the location of specimens, but the even greater disadvantage that species are planted as near neighbours that only grow healthily under widely differing environmental conditions. Since the purpose of the living collections is to supplement the knowledge provided by herbarium specimens—for habit and reproduction are important characteristics concerning which dried specimens furnish little information—the growth of species in a suitable environment is of considerable importance. In the culture of species under glass, specimens have perforce to be aggregated according to their requirements, but out of doors initial steps had been made towards an ecological grouping when the rock garden and water gardens were laid out. To these have recently been added a chalk garden where calcicole plants, both native and exotic, are cultivated. Such grouping has an educational as well as cultural value.

The economic houses are a part of a group of houses known as the T range where, besides a collection of economic species, many tropical and sub-tropical plants are grown. Sources of drugs are, for example, represented by such plants as the Peruvian *Erythroxylon coca* (cocaine) and the South African *Strophanthus hispidus* (strophanthin); of spices by *Myristica fragrans* (nutmeg) from the Moluccas, *Eugenia caryophyllata* (clove) and *Pimenta officinalis* (allspice) from tropical America; food plants include *Dioscorea* spp. (yams) and *Manihot palmata* (cassava); beverage plants include *Thea*, *Coffea* and *Theobroma*; textiles are exemplified by such plants as *Gossypium barbadense* (Sea Island cotton) and *Musa textilis* (Manila hemp), whilst the fruits of other lands are represented by species of *Citrus*, *Cyphomandra*, etc. The species grown in the tropical range are too diverse in their requirements for successful reproduction to be entirely achieved, and until a new monsoon house is erected, many of the species, which require a warm wet season alternating with drier and cooler conditions, cannot be satisfactorily grown.

The Amazon Water Lily

Nevertheless, despite the compromises and make-shifts which present conditions impose, that remarkable annual, the *Victoria amazonica*, flowers and fruits every year, and is not only a delight to hundreds of thousands who come to admire the beauty of its structural efficiency, but is the source of seeds distributed to most of the botanical gardens of Europe and the East. Here, too, the *Gloriosa rothschildiana* and its congeners flourish as in few other places, and the Allamandas provide a golden canopy, whilst in the nearby Nepenthes House, and another house adjoining, a noble collection of the insectivorous plants can be studied showing the diverse ways in which this method of supplementation of the nitrogen supply is assured.

The Temperate House, the largest glasshouse at Kew, and perhaps in the world, serves to protect a collection of species chiefly from New Zealand and Australia. Here can be seen Australian Acacias with their phyllodic foliage or that curious New Zealand conifer *Phyllocladus*, Epacrids and Fuchsias from the southern hemisphere and numerous leathery-leaved members of the Proteaceae that furnish admirable material for the investigation of the anatomical structure of drought-resistant leaves. Here, too, are the bottle brushes (*Callistemon*), and a marvellous group of tree ferns that are a tribute to the cultural skill that goes to the maintenance of this assemblage of plants from Australasia notorious for the difficulties attendant upon their culture. Here, too, is the remarkable fern *Thyrsopteris elegans*, only native to the island of Juan Fernandez.

In the Temperate Fern and Tropical Fern houses, a large range of Pteridophytes can be seen, including a large collection of Selaginellas and cryptogams, from the little water fern *Azolla* to the giant *Cibotium wendlandi* from Guatemala, with fronds sixteen feet in length, and the Marattiaceous ferns whose appearance like that of the Cycads has an indefinable anachronistic quality that such 'living fossils' share with the Maidenhair tree, *Ginkgo biloba*. By contrast, the filmy ferns and liverworts, cultivated in a special house providing a dim light and a very humid atmosphere, are almost aquatic in their incapacity to resist drought.

Still other houses contain collections of tropical aroids and desert succulents. In the latter the pebble-like *Lithops* present a mimicry that is quite remarkable, but not more so than the adaptation to drought resistance of others, which is so marked that the watering can is their greatest enemy. Here can be seen parallel development in the plant world in its most striking manifestations so that, except when in flower, a species of cactus and a species of *Euphorbia* may be so alike that only the expert can distinguish them unless they are injured, when the milky juice of the one and the watery juice of the other reveal the difference.

The Palm House, built nearly a century ago, is 362 ft. long and 66 ft. high, yet despite its large size is so well proportioned as to look far smaller. This houses a selection of palms including the magnificent Fijian Pritchardias, the fan-leaved Indo-Malayan *Livistonia*, the rare Madagascan *Bismarckia nobilis*, also such interesting species as the Double Coconut, *Lodoicea sechellarum*, confined to the Seychelles and bearing the largest fruit known. But here, also, is a large collection of Cycads which not infrequently

produce cones, both male and female, which (especially the latter) are greatly prized by botanical departments where surplus material of this character is sent for purposes of research.

For many visitors to the Gardens, the Rhododendron Dell in June and the Magnolia collection in late spring are magnets that bring hundreds of thousands to gaze upon their beauty. But of equal significance scientifically is the large collection of coniferous and broad-leaved trees which, though less spectacular in their flowers, are of greater economic importance. Over 400 different kinds of Rhododendron are in cultivation at Kew, but a greater problem is presented by large trees such as the Oaks, of which more than a hundred species are grown; limitations of space preclude their adequate representation by specimens of varying age whilst many of the timber trees in this and other genera demand more space for their effective development than can be spared.

In the Rock Garden the greatest number of species is to be found in a small space, and here are displayed the contributions of a common environment from the most diverse families and geographical regions. To the student, however, the herbaceous beds, each devoted to a family or tribe, offer the best opportunity of studying the remarkable plasticity of plant form and the diversity of variations on a common theme. Here, for instance, can be seen *Eryngium ebracteatum*, with foliage like a Monocotyledon and flower heads like a Salad Burnet; were it not for the typical structure of the small flowers no one would imagine that this plant had anything in common with the giant Hogweed. Or we scan the twenty-nine beds devoted to the Compositae, each filled with many species, and we gain some idea of the wealth of variety in this family, where the flower-like inflorescence can range from the simple but deceptive yellow star of *Lactuca viminea* to the complex organisation of a Globe thistle. These 'Order Beds' perform a dual function in that they display the range of structure which each family exhibits and also serve as a museum in which the herbaceous members of the groups can be assembled.

Kew's Wartime Contribution

During and since the war a part of the gardens was set aside as a demonstration plot of fruit and vegetables, a feature that not only attracted a large and appreciative body of visitors but proved the means of helping many to achieve greater success in their own efforts at food production. As part of its wartime contribution Kew played a major part in the exploitation of rosehips for Vitamin C and also investigated the possibilities of utilising the 'rubber dandelion', *Taraxacum kok-saghys*, for which purpose numerous experiments were carried out and rubber determinations were made on a considerable scale.

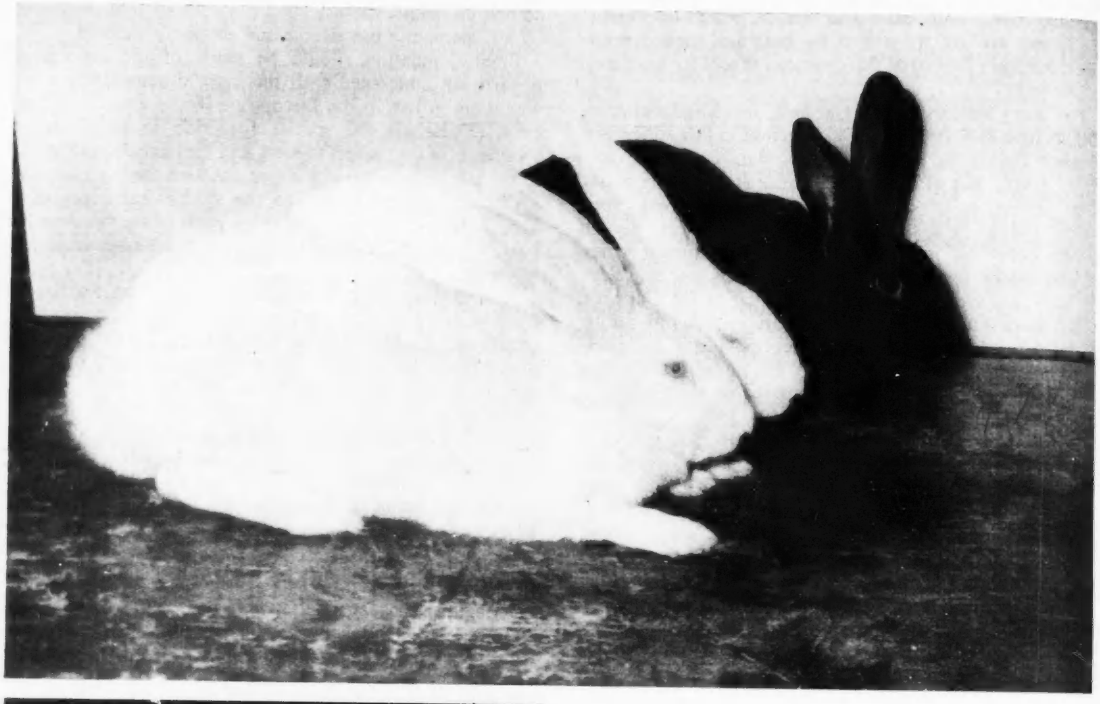
The use of the rose ends of potatoes was also successfully demonstrated as a means of conserving the food supply and materially reducing the weight and bulk as compared with ordinary seed potatoes so that transport by air becomes a practicable and economic method.

Finally, mention should be made of the decorative department concerned with the more ornamental species which are grown in the Decorative House and the flower beds. These are the special attraction to hundreds of thousands of the visitors to Kew, and the recreation afforded to these is perhaps no less important than the horticultural instruction afforded alike to the student-gardeners who assist in the care of these and other parts of the Gardens as part of their training and to the visitors with horticultural interests.

It is obvious from what has been said that the Royal Botanic Gardens and the departments therein comprised constitute at once a unique organisation for the study of plants from many aspects and a source of research material that is drawn on by the whole civilised world. If the exchange of material and information has developed more extensively throughout the Empire and America, it by no means stops there, and the contacts with China and the Far East, with Russia and the Continent, that were ruptured by war are being re-established on the basis of friendly co-operation.

A Succession of Famous Names

No account of Kew and its work, however cursory, would be complete without some mention of the scientists who have worked here. Reference has already been made to Sir William Hooker, the first director, and to his son, Sir Joseph Hooker who succeeded him, both of whom played so important a part in developing Kew and in the advancement of taxonomy. The third director was Sir William Thistelton-Dyer, who did much to further the study of geographical distribution of species, and he was succeeded in turn by Sir David Prain and Sir Arthur Hill. The Keepers of the Herbarium included notable taxonomists such as George Bentham, Daniel Oliver, J. G. Baker, Botting Hemsley and Stapf. Just as students of classification came to utilise the Herbarium, so investigators have used the facilities of the Jodrell Laboratory to study the living material provided by the Gardens. Much of D. H. Scott's work on the fossil plants of the coal measures was carried out when he occupied the position of Hon. Keeper of the Jodrell Laboratory, and there, too, Brown and Escombe carried out their classical researches on photosynthesis, and Walter Gardiner investigated the protoplasmic connexions between cell and cell. Amongst other distinguished botanists who have worked here, mention may be made of Professor F. O. Bower, who carried out studies on Ferns, and F. E. Fritsch who investigated Algae, Miss Ethel Sargant who worked on Cytology, Professor Weiss who investigated Graft Hybrids and Professor Skottsberg who studied *Splachnidium*. Limitations of space preclude enumeration of the distinguished investigators who have worked in the Herbarium as this would involve a catalogue of nearly all the great names of taxonomy of the past century.



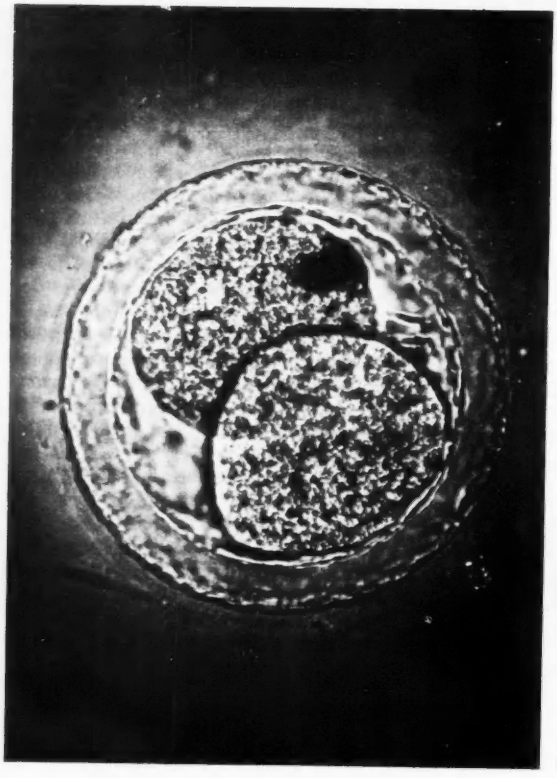


FIG. 1 (*above*).—The two white Californian rabbits with their 'incubator mother', a black English doe. The young rabbits are larger than the doe because they belong to a considerably bigger breed.
FIG. 2 (*left*).—One of the rabbit eggs shortly after it was taken from the Californian doe in Boston, Massachusetts.
FIG. 3 (*below*).—One of the phials in which the eggs were sent by air across the Atlantic.
(*Figs. 2 and 3, by courtesy of "Farmer's Weekly".*)

Transplanted Embryos

A RADICALLY NEW TECHNIQUE IS ADVANCED BY AN INTERNATIONAL EXPERIMENT

THE two white rabbits shown in the photograph reproduced on the opposite page have made scientific history.

A white Californian doe conceived them in America but a black English doe gave birth to them in Britain. They were taken from their true mother a few hours after they had been conceived in Boston, Massachusetts, flown across the Atlantic and then transplanted into the black doe in Cambridge, England. Thirty-two days later the black doe gave birth to them in the normal way.

Here are the details of this extraordinary experiment:

Two pure-bred does of the white Californian breed were inseminated with semen from a pure-bred Californian buck at the Worcester Foundation for Experimental Biology at Boston University. They had previously been given an injection to increase the number of eggs released by their ovaries.

About twenty-four hours after insemination Dr. M. C. Chang killed the does and obtained from them 74 fertilised eggs which had just begun to divide.

The eggs were placed in four small phials containing rabbit semen. A drop of penicillin solution was added to each phial to prevent bacterial attack. The phials were packed in a vacuum flask containing ice. The flask was then shipped from Boston by air to London and then by train to the School of Agriculture at Cambridge University.

Meanwhile at Cambridge Mr. W. G. R. Marden, working to a timetable carefully synchronised with Dr. Chang's, had prepared two black does to receive the eggs.

The does had been treated so that their reproductive organs and sex hormone systems were at appreciably the same stage of the heat-cycle as those of Californian does in Boston.

Marden transplanted ten of the fertilised eggs in the Fallopian tubes (egg tubes) of each black doe by a kind of Caesarian operation in reverse. One of the does gave birth to two white offspring 32 days later.

The young rabbits bore no 'blood relationship' to the doe which gave them birth. So far as could be ascertained, their inherited features were all derived from their true American parents. In spite of the intimate contact between the developing rabbits and the black doe which incubated them, there was no evidence that these inherited features had been influenced in any way. The white rabbits were normal specimens of the Californian breed.

This spectacular experiment represents a step forward in a long-term research project which may eventually have profound effects on agricultural practice.

As previously explained in DISCOVERY (Feb. 1948), the transplanting of mammal eggs offers a possible means of improving the world's cattle stocks at an unnaturally rapid rate. The relatively few cows which are able to transmit a high milk-yielding capacity to their daughters provide only an average of four or five calves each. But if they could be used without injury as a source of eggs which could be incubated in poor-quality cattle, dairy stocks of the highest grade genetically could rapidly be established.

The possible transport of fertilised mammal eggs by air as pioneered in this Anglo-U.S. experiment offers a means of spreading the best strains of domestic animals without shipment of the parents abroad.

The time interval between the extraction of the fertilised eggs from the white does in Boston and their implantation in the black does in Cambridge was only 27 hours, but Chang has proved that rabbit eggs can be kept alive at refrigerator temperatures for at least several days. If the period of storage can be extended indefinitely the prospects are somewhat fantastic and even perhaps rather frightening.

Dr. A. S. Parkes and his colleagues at the National Institute for Medical Research have proved that mammalian semen can be kept alive for 20 weeks and possibly longer by mixing it with glycerol and storing it at a temperature of −79°C., the temperature of solid carbon dioxide. The sperms retain their fertilising capacity and a pregnancy rate of nearly 80 per cent has been obtained in experiments in which bull semen stored for eight days was used.

The combined storage of mammalian eggs and sperms would seem to open up the science fiction prospect of producing offspring long after the death of their parents.

On the immediately practical side several important advances have been made in the cattle transplantation project since my first report in DISCOVERY four years ago.

Scientists of the U.S. Bureau of Dairy Industry have transplanted a cow ovum which developed completely and was born as a normal living calf. The incubator was a yearling Holstein heifer and the egg was introduced by operation. (For the process of transplanting mammal eggs the British scientist R. A. Beatty has proposed the term 'inovulation' by analogy with the word 'insemination'.)

In this experiment the scientists had to slaughter the donor cow to obtain the eggs but Rowson of Cambridge has devised a simple instrument which can be introduced into the womb of the cow to extract the eggs without injury.

In experiments at the Texas Agriculture Experimental Station scientists have successfully transplanted sheep and goat embryos. They even tried transplanting a sheep egg into a goat incubator. The embryo eventually was aborted, but development proceeded for fifty days—showing that there is a possibility of a goat giving birth to a sheep!

It seems that before our children are much older we shall have to scrap the old riddle which asks "What is it that a cat has which no other animal has?"

The answer used to be *kittens*.

CHAPMAN PINCHER

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In Britain, comparatively few scientists have written for the lay press, and even fewer have seen service as a science correspondent for a national newspaper or magazine. Derek Wragge Morley, who was science correspondent for "Picture Post" for three years, is one scientist with practical experience in this field, and in the article printed below he gives his views about science writing for mass-circulation journals.

Scientists and the Press

DEREK WRAGGE MORLEY, M.A., F.L.S.

THESE comments are written as a result of my three years' experience as the *de facto* Science Editor of *Picture Post*, a leading national weekly. Following my resignation I received a variety of comments from my scientific friends all of which followed much the same pattern. I should like to quote from two of these because they illustrate so clearly the problems facing both the scientific journalist and the scientist. First, from a professor at one of our older universities: "I suppose the break with *Picture Post* was inevitable sooner or later; but at any rate you can now claim to be one of the very few people in this country who have inside knowledge of both the scientific and the journalistic worlds." The second was from the leader of a research laboratory. Following a purely personal comment about my leaving, he goes on, "but it must have been a difficult world for anyone with good scientific standards".

I do not wish to discuss personal factors, but the reactions of these two scientists is typical. Before I became a more or less full-time scientific journalist, somewhat by accident, I had been engaged in scientific research. These comments are to some extent a reflection of the feeling which is common among scientists that scientific caste is lost by indulging in 'popular' writing.

This feeling about loss of caste is derived from two main things. First, the scientist feels that in writing popular articles, especially under regular contract, you may be sacrificing your soul for money; the pay for such work he believes to be quite disproportionate to the amount received by a scientist for his research and academic teaching. The scientist who argues this way takes an idealistic view of his own job, regarding it as a mission beyond the touch of monetary considerations. He feels that too close a contact with money, easily obtainable, must have a bad effect. There is, of course, some small grain of truth in this, although science writers in general will smile somewhat hesitantly at the idea that it is easy to get big money for this class of writing. Any suggestion that popular writing may also be regarded as a mission is met with a polite agreement that, "it should be, *but* . . ." And there one reaches impasse, for the 'but' in my experience is more important than the theoretical agreement. A few scientists, of course, disclaim the whole idea that there is any need for the public to know about their work; their work is above the world, let it spurn it, or use it, as it wishes. This attitude is, however, rare, and is getting rarer. Now there is no question that much of this feeling on the part of the scientist is, if he will be honest, basically due to his failure to understand the difficulties and special needs of popular writing. Only rarely has the scientist the ability to present his work in popular form. Quite apart from the technical problems involved in newspaper and magazine production, it is a hard discipline that has to be learnt, often through ill-paid years. The underdogs are perhaps less well paid in science than in journalism, but they lead a securer, quieter, and usually less harassing life. On the whole, the higher posts are well paid in both professions, although I think it would be generally agreed that the academic scientist is often underpaid for much of his life. But once settled in his job, the scientist is secure, even though he were to prove inefficient. In contrast, few inefficient journalists survive long in Fleet Street.

The second reason why scientists feel that popular writing involves a loss of caste, is because it is not a fundamental activity. In the eyes of the scientist the science writer is not creative and is to some degree parasitic in his dependence on the scientist for his material. To put it another way, the scientist tends to regard science writing as the intellectual equivalent of second- or third-rate applied research.

At the same time it might not do scientists any harm to try both to write and to read more of their work in a language which the ordinary person can understand. The special terminology of the scientist is today so vast and, moreover, so loaded with historic associations of ideas, that it can do real harm by preventing simple and direct thinking. Frequent escape from scientific terminology will often help the scientist to find out what is really being said, thought, or described. Too often these technical terms, as has been said in a scientific paper, "hide the perhaps unwitting ignorance of the writer". Too frequently something, which seems to be an adequate *explanation* of events when written in scientific terminology turns out to be, when translated into plain English, only a *description* of events. Also it is still true that fundamental concepts—the framework behind each scientist's specialised work—are normally discussed in a few simple and carefully chosen words. Indeed, the fact that these concepts can be reduced to plain English is a reflection of their inherent simplicity.

In these days when the synthesis of the vast mass of specialised scientific work into a working compass of general theory is a constant problem of major importance, an increased application by the scientist of the simple English of our ancestors to his own work would be a good thing.

In this connexion I think it is too little realised how important a part scientific journalism plays in keeping scientists informed of scientific developments in other fields. This is not so just in the case of a journal like *Discovery*, but also in the case of the general Press. With the exception of *Nature*, technical journals are either

limited too much in scope, or in their circulation and general contact, to play much part in this.

No one can pretend that the Press always manages to do adequately either this job or their primary one of informing the general public about scientific developments.

This may be partly due to the fact that science is too often a mystical word to the news editor. At the same time he also regards it as a world of facts: scientific news is to him hard news of real facts, not surmise. That these apparently contradictory outlooks can exist together is partly due to the belief among some news editors that what they can't understand is either bunkum, moonshine (which has news potentialities), or something awe-inspiring. There is no doubt that news editors in general are rather lost when it comes to handling scientific news. Here the news editor tends to have a somewhat excessive respect for degrees and other academic qualifications, but does not generally appreciate their real significance. This makes the task of the news editor difficult. He cannot understand, for example, that the Emeritus Professor may often know less about the research in progress than the young Ph.D. or D.Sc., or the young Reader or Professor still at work in the laboratory, whose names cannot be found in the hand-picked catalogue comprising *Who's Who*. He tries to apply the same laws to the scientific world that he is so used to applying to personalities in other fields. In doing this he often (although not always) finds himself appealing to an inadequate list of a few regular 'names' for comment on all scientific news that comes into his net. If they have not the time nor the inclination to comment, he may contact the head of an organisation, or more rarely a laboratory, and when he does this, he is too often sent away puzzled or unsatisfied. If he is lucky and finds co-operation and is referred to a working scientist, he is faced with the further difficulty of choosing a suitable person on his staff to deal with the story, for few papers have specialist science writers on their staffs. In the absence of such writers the result is nearly always unsatisfactory. Moreover, it is difficult for the news editor to assess the news value—i.e. interest and significance—of the science stories which eventually do get written. He doesn't want to be presented with what the scientist thinks is the news value of his work, that is his, or his trained reporter's, task to judge. Only if the full story is simply and intelligibly explained can he weigh its real news value. But to do this properly he needs to have before him the backcloth to the particular scientific news item. It is the failure of the news editor to get this picture, and the failure of the scientist to realise this need, that is the major cause of friction between scientists and the Press today. It is the cause of bad science reporting and the subsequent irate protests from the scientists. It will be clear from this that there is an essential need for the specialist science reporter; for the man who has sufficient all-round scientific knowledge to place the particular piece of scientific work against at least a rough general background. To assess, in fact, both its general scientific importance and its journalistic news value. He can then present the matter properly to the news editor, both pointing out the journalistic possibilities and presenting the general background, while explaining the scientist's viewpoint. It is this experienced weighing of both journalistic and scientific points hand in hand, that leads to good science writing and prevents those *gaffes*, and misrepresentations which too often occur. Perhaps the greatest condemnation of the Press in this respect is the fact that barely half a dozen national weeklies and dailies employ specialist science editors, writers or correspondents, though many more have experimented in this direction, unfortunately without success. This failure may be due to their not realising the special qualifications needed if the job is to be well done. The work of a good science writer should come up to every standard of news criticism of the paper concerned. But there should be no interference because of the bumbling of some antediluvian and probably ill-informed acquaintance met by the editor at his pub or club. This, in fact, does not happen where the science writer keeps his editors well informed with adequate background material. But having got his man, the news editor must trust his judgment and accept his advice.

Scientists will say there are still troubles; things still go wrong, and, "we can never be sure what will happen once we let the Press in". Also, no doubt, the scientist does not like the idea of the journalist choosing the news points. He knows the important points of his work and his fellow scientists will think him a fool if the work is presented with something different as its main interest—something perhaps that is not even novel and certainly not important to him.

It is a fact that the life of the universities, and especially of the older ones, is very parochial. This applies almost as much to each field of science, and especially to the laboratory communities. The headlined scientist is open to much criticism from his colleagues, but the importance of this should not be overrated. Often a professor may have a personal dislike of the Press, or someone doing really brilliant work, on the other hand, may feel a genuine grudge because his work gains no public recognition. There is no real solution to this problem but it can be alleviated. It is the duty of the science writer to do his best to follow science adequately through the specialist journals, check the facts given in his article and see that the credit is fairly distributed. An adequately trained assistant can be of much help in this respect.

The scientist, on the other hand, must realise that his work, however important in its own field, may not be of interest to the general public. Alternatively, its main interest and importance to the public may not be in the scientific importance of the work, but in its instructional value as an example of the extraordinary things that scientists have to do in order to increase our knowledge and make new discoveries possible. Really fundamental discoveries are, however, always of interest.

If the scientist still feels disturbed and argumentative, he should remember one further point. He has a duty to render information to the public, an educational and a social duty. It is educational in that the public must provide the best of its offspring to be his followers, and normally school education does not excite the real urge for scientific service that a wider knowledge of its achievements, its scope and its diversity, learned from the popular press, can do. Also few purely private or academic grants remain and public money is spent to aid the scientist's work. The public, therefore, has a right to know what is being done.

The task of the scientist, then, is not to ban the Press but to help the Press to do a good and worthwhile job. And the Press in its turn must realise what harm it can do when it does its job badly. While there may often be a justification for criticism of the Press, there is nevertheless a greater spirit of willingness to learn and experiment today than ever before.

One wartime survival deserves further comment: the Public Relations Officer. He could be invaluable in helping the journalist in many ways, such as arranging meetings, laying on photographing facilities, and maintaining a steady flow of information. In many cases, especially with commercial firms, he is just this paragon of extra aid and liaison. But all too frequently he is more akin to a buffer placed between the scientist and the Press, to prevent by his very understanding of journalists, the success of their inquiries. This may be necessary on occasion, as in the field of atomic physics, but it is overdone to a ludicrous extent and leads almost inevitably to the speculation and half-guesses put over as fact, which so annoy the scientist.

The chief failure of the P.R.O. is his inability to understand that science news means detailed scientific fact of a quality that the specialist writer can assess—both background facts and special points. His news hand-outs are too often naïve and inadequate. If detail is lacking, then the science journalist must needs draw on the corpus of his own scientific knowledge and that of his scientific contacts, to help him fit the released news item into its proper background. If the results annoy the laboratory concerned, it has only itself to blame.

One other field deserves comment, for even in the national press, it is news, like it or not. That is science fiction. It is news and fun, let's face it, and even today almost made respectable by the indulgence of the eminent. But in the news-reporting press it raises a problem that must be faced. It must be of fair quality, and not too ignorant of the scientific actualities. It must also be clearly designated as fiction and qualified in this way as separate from the factual science content more usually found. These may seem simple rules, but they are too often neglected. Its real place is in the comic papers, literary journals and special science fiction magazines. Its danger is that too often it misleads the young by giving a false picture of the aims of science and the way in which the scientist works. But better science reporting will soon lead to better science fiction, and better science reporting depends on a deeper and more sympathetic understanding of the problems involved both by scientists and the Press.

It is inevitable that science will go on being reported to an ever-increasing degree, and the sooner the special difficulties involved and the need for specialist science journalists are realised, the quicker the present friction and misunderstandings will disappear in the light of the greater efficiency that will ensue.

One final point: when the scientist does himself write for the Press, he must do so prepared like anyone else, to realise the needs of the paper concerned, submitting himself to the editor as the specialist in his own field of newspaper or magazine production. If he is not prepared to accept this, he should not undertake the task.

The End of the Village Gasworks

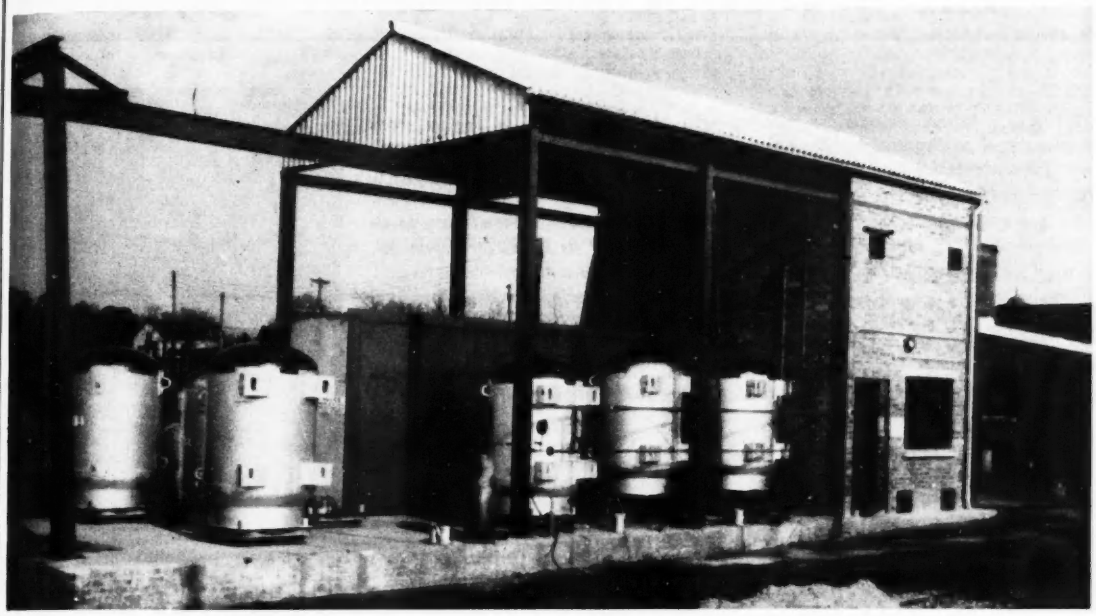
ONE of the village industries which is passing out of existence without much notice being taken, is that of gas-making. During the last hundred years the village gasworks has become one of the permanent features of village life, like the church, the chapel and the public-houses, and there will be some who will feel a sentimental pang at its passing. "You take that lane on the right, and go on past the gasworks" one can imagine the older inhabitants saying, "but ther bain't any gasworks there any more."

The chemical process which has been carried out at these small works for perhaps a hundred years or more is the destructive distillation of coal, out of contact with the air, to produce coke and coal gas. The latter has to be purified to remove tar, hydrogen sulphide and ammonia before being distributed to the locality through the street mains. Like most chemical processes, however, this one is inefficient when carried out in very small units. Whereas a large coke-oven or gasworks may operate at an efficiency of 75 per cent or even 80 per cent, the village works may well be under 50 per cent; moreover, the labour costs are disproportionately high.

One factor which is closing down the small works is the development of long-distance pipelines bringing gas from larger manufacturing units. For example, a scheme for a projected gas grid to supply Cambridge, Norfolk and Suffolk and a good part of Hertfordshire with gas generated in Derbyshire has been put forward recently.

Another development which is perhaps of greater interest to the scientist is the use of butane-air in place of coal gas in rural areas. The use of liquid butane (sold under such trade names as 'Calor Gas', 'Bottogas' etc.) in isolated homesteads, boats, caravans, and so on is of course already well established. The butane is supplied in the liquid form, under a pressure of a few atmospheres, and the gas evaporates from the surface of the liquid as required—i.e. as the pressure of the vapour falls with the opening of the tap on the appliance.

Now that more of this useful hydrocarbon is being produced in Great Britain—due to the increasing number of refineries and the widespread development of catalytic cracking—the possibility emerges that a small gasworks could quite profitably be replaced by a simple plant for carburetting air with butane vapour. This, in fact, is what is being done at the village of Whitland (between Carmarthen and Tenby) where a pioneer installation has been put up by the Wales Gas Board to test out the possibilities of the idea. Although this is a remote and rural area, it is not far from the big oil refinery of Llandarcy, near Swansea; and butane is brought from there in tanks holding a ton or more of the liquid.



The Whitland experimental gasworks. The containers hold a ton of liquid butane apiece. The mixture of butane and air which is piped to local houses has approximately the same heating value as coal gas.

The word 'refinery', is of course, something of a misnomer today, for the old conception of a plant merely to separate out the components of the crude oil by fractional distillation has largely disappeared. The modern refinery breaks up most of the heavier hydrocarbons by a cracking process, to produce a larger proportion of oils in the petrol range than would otherwise be available. It is during this cracking process that the propane and butane are formed —the 'liquefiable gas' fraction—boiling at —42°C. and 0°C. respectively. Some idea of the importance of these substances to our national resources in the near future may be gauged from the fact that British production, it is estimated, will reach 600,000 tons per annum by 1954. Perhaps one-quarter of this will be needed as a starting-point for chemical manufacture, the rest being available as a fuel.

In many countries abroad (particularly the U.S.A. and France) a butane-air or propane-air mixture is being widely adopted for small gasworks remote from any grid. The price usually compares well with coal gas made by the traditional process, and most gas-burning apparatus can be converted to the new fuel fairly easily.

As will be seen from the photograph of the Whitland plant, the apparatus needed to produce this mixture is remarkably small and compact; also it needs no attention, so long as someone is on hand to deal with any difficulties when summoned by the automatic alarm signal. The proportion of air to butane usually chosen is about 4 to 1; the resultant mixture has about the same heating capacity as an average coal gas.

The idea of the supplying of a butane-air mixture through the pipes of the gas distribution system may sound hazardous to some. There is, however, no danger of explosion; one has to go to a very much higher proportion than this (about 12 to 1) before one reaches an explosive mixture. Mixing air with the hydrocarbon has, however, several big advantages: (a) it makes it possible to burn the fuel with an aerated flame without employing pressures any higher than is usual with towns gas; (b) it reduces the loss caused by any leaks in the pipelines; (c) it gives the same heat throughput per burner as with towns gas.

Naturally, however, one cannot simply change over from towns gas (roughly 50 per cent hydrogen, 25 per cent methane, 15 per cent carbon monoxide, and the rest inert) to butane-air (25 per cent butane, 75 per cent air) without any alteration to the burner. The flame is always in a delicate state of equilibrium between the rate of flow of the gases outwards and the rate at which flame propagates itself in the opposite (upstream) direction. Hydrogen has a much higher flame velocity than any other known gas, and consequently flame propagation in a coal-gas burner is a much faster process than in the case of butane-air. The rate of egress of this gas must be correspondingly lowered, or the flames will dance off into the air and leave the burner entirely. At Whitland, therefore, it has been necessary in most cases to enlarge or multiply the holes in the burner at which the flames are seated.

There is little doubt that before long many of the village gasworks will be following Whitland's example. Two more such plants are being erected in Wales and, in East Anglia, Bungay and Framlingham will shortly be converted.

In this area another variant will shortly be tried—water gas (made by blowing steam through red-hot coke) enriched with butane. This is a pattern of gas manufacture suited to the not-quite-so-small unit which can afford a little more capital cost in order to economise on the basic materials.

LESLIE T. MINCHIN, B.Sc., M.Inst.Gas E.

The British Association at Belfast

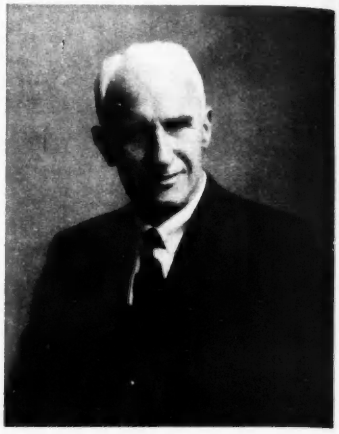
This year's British Association meeting—the 114th—was held in Belfast from September 3 to September 10. The membership figure of 4643 was the largest ever for a provincial meeting; indeed only once has the B.A. ever achieved a higher figure—and that was for the centenary meeting held in 1931 in London.

A special feature of the meeting was the series of lectures arranged for school-children. This "Junior British Association", the first of its kind ever organised, proved very attractive, and over 900 junior members were enrolled.

The inaugural ceremony on September 3 in the Sir William Whitla Hall of Queen's University opened with the conferring of honorary degrees by the University's Chancellor, Viscount Alanbrooke, upon the B.A. president (Prof. A. V. Hill), and upon Dr. D. W. Bronk, Dr. E. D. Adrian, Sir William Slater and Sir Richard Southwell. The presidential address (which we published in last month's issue) then followed.

The Duke of Edinburgh, the retiring president, was present at the opening ceremony, and attended several other B.A. functions.

Below we publish excerpts from a selection of papers delivered to B.A. sectional meetings.



Prof. A. V. Hill

The Dependence of Atomic Energy Programmes on Chemists

THE importance of chemists in the various programmes for developing atomic energy was stressed by Prof. W. WARDLAW, head of the Chemistry Department of Birkbeck College, in his address to Section B (Chemistry). He said, "Because of the physical principles involved it is sometimes said that atomic power is principally the concern of physicists. Obviously anyone concerned with this field of work should be familiar with the basic facts of nuclear physics. However, it may be stated quite fairly that the economic future of atomic energy calls for the close association of scientists and engineers and that the rôle of the chemist is a vital one. Basic studies of corrosion phenomena are of considerable importance, whilst the search for new materials for constructional purposes is imperative. Most of the elements have been surveyed for their neutron absorption, and as a result special attention has been focused on the chemistry and metallurgy of beryllium, zirconium and other metals and alloys."

Prof. Wardlaw called his address "The Advancing Front of Chemistry", and he referred to a number of recent chemical developments of industrial importance. He mentioned zirconium. This metal has excellent corrosion resistance, and its very small affinity for neutrons commends its use as a structural material in atomic power plants. Prof. Wardlaw spoke of the increasing importance of titanium (which is finding applications in jet engines) and germanium.

A new type of blast-furnace, built at Liége in Belgium as a result of co-operation between experts of nine countries (including Britain), may lead to a revolution in iron- and steel-making, said Prof. Wardlaw. This blast-furnace will run on pure oxygen instead of air, and the exploitation of the new technique would necessitate the making of oxygen by the ton.

Prof. Wardlaw directed attention to the extensive use of chemicals in food processing, and the dangers arising through the introduction into foodstuffs of substances capable of affecting the health of the eater. He said, "The food processor has chemicals for every need—preservatives, emulsifiers, colouring agents, flavours of all kinds, flour 'improvers', anti-staling and anti-rancidity agents, sweetening agents, anti-oxidants and antiseptics. Some idea of the magnitude of this problem of chemicals in food can be obtained from the report of the Delaney Committee which was set up in June 1950 by the United States Congress. It was given the task of assessing the dangers to public health arising from the increasing use of chemical substances in food manufacture, and from the presence in foods of residues from the pesticides now widely employed in agriculture. The committee heard the striking evidence from the officers of the Food and Drugs Administration, that 704 extraneous substances were thought to be in use. Of these, only 428 were considered harmless as normally employed, leaving 276 of which the safety was open to question. Consideration was given not only to those substances which are added to foods to produce some desired effect, but also to those compounds which may become associated with foodstuffs by accident. Examples are pesticides such as DDT which may adhere to crops and find their way into foodstuffs. Experiments were described which demonstrated that DDT appeared in the flesh of chickens, cows and sheep which had eaten crops sprayed with the pesticide. It was present also in eggs and milk. Other pesticides are even more highly toxic. There is now a substantial body of opinion in the United States which favours legislation to deal with the various problems outlined above, and this proposal is supported by members of the medical profession and others working in the fields of biochemistry and nutrition."

Amoeba's 'Tail'

THE animal called *Amoeba* figures in every biology course, and has been observed by hundreds of thousands of students. The stage was reached long ago when a new discovery could be expected to arise from the study of this creature. Yet such a discovery was announced in a paper by Dr. R. J. GOLDACRE of the Chester Beatty Research Institute, which is part of London's Royal Cancer Hospital at Fulham.

Dr. Goldacre stated that *Amoeba* seems to have a definite tail and a definite polarity. By means of diagrams and a film it was shown that *Amoeba* never reverses but moves on a relatively steady axis. Placed in a narrow channel in which it could not turn round it would stream to the end, put out a pseudopodium, and move back by squeezing about that. Red pigment, which is generally scattered more or less evenly through an *Amoeba* when it is stationary, becomes concentrated at one end—the wrinkled end at the rear—when the animal moves.

Contraction in that end, it could be shown, generated electric current which passed through the whole of the cell giving it impulse. The wrinkled tail area was also the point of the furrow which appeared when the *Amoeba* was about to divide and, if anaesthetised, the outer membrane lifted away from the granular cytoplasm except at the wrinkled area where it did not. From the tests and observations he had carried out, Dr. Goldacre said it was fair to say that the tail played a fairly dominant part in the life of the *Amoeba* and was a relatively constant part of it. It was remarkable how that tail had been so persistently ignored by zoologists.

How Bees Defend their Hives

Two scientists of the Bee Research Department of Rothamsted Experimental Station, Dr. C. G. BUTLER and J. B. FREE, told the Zoology Section about observations they had made of the behaviour of bees at the hive entrance in order to ascertain the relative importance of scent and behaviour in enabling a bee to recognise members of their own colony and to distinguish them from intruders from other colonies.

It has been found that bees do not guard the entrances of their hives unless their colonies have been 'alerted' either by the presence of robber bees, or of numbers of bees that have strayed from other colonies.

The guards, which may be either young or old bees, assume a characteristic stance with their forelegs raised from the ground. They attempt to intercept and inspect with their antennae any bees which alight near the entrances of their hives. They recognise members of their own colony by scent very quickly and subsequently ignore them. Possibly this is explained by habituation to the odour of members of their own colonies. Most intruders from other colonies are also quickly recognised by their scent and are mauled by the guards.

Robber bees are recognised as such by guard bees on account of their characteristic swaying flight before the hive, rather than by scent. This characteristic flight of the robber releases a series of behaviour patterns on the part of the guard bees. As soon as a robber alights the guards attempt to seize her and sting her to death. If seized the robber tries to escape, but if this is impossible, grapples with the guard and attempts to sting her.

Laden foragers which attempt to enter the hive of another colony assume a dominant attitude towards the guards and enter the hive without hesitation or difficulty.

Intruders, other than robbers and laden foragers, assume a submissive attitude when intercepted by guards and submit to examination or mauling, the guards attempting to drag them away from the hive entrance. If a guard approaches the head of a submissive intruder the latter offers her food between her mandibles. Such food is usually refused. After it has been refused several times the intruder commences to 'strop' her tongue in a manner that is similar to, but differs in several particulars from, normal tongue cleaning.

Occasionally when a bee is being severely mauled and suddenly loses her hold on the ground she feigns death, and in this passive state is carried round by the guards.

Submissive intruders are not stung by guard bees. Sometimes, however, a hitherto submissive intruder attempts to escape from a guard bee whereupon the latter immediately attempts to sting her.

Even when submissive intruders have succeeded in entering the hive of a strange colony they are examined and mauled on the combs and often dragged out of the hive. After a few hours, however, they acquire the odour of other members of the colony and are adopted by them. Such adopted intruders have been seen twenty-four hours after joining a strange colony guarding the entrance of the hive of the adopted colony against intruding members of their former colony.

The conclusion of Dr. Butler and Mr. Free was that although scent plays an important part in the recognition of all intruders, except robbers, it is the subsequent behaviour of the intruder which determines the actions taken by the guard bees towards them.

Radioactive Tracers in Bee Research

THE remarkable extent to which honey bees share the nectar they bring back to the hive was described in a paper which Mr. C. R. RIBBANDS of Rothamsted Experimental Station read to the Zoology Section. He referred to one particular experiment in which six bees, from a colony of 24,500, were trained to collect sugar syrup from a dish. Another dish was substituted, which contained one tablespoonful of syrup to which a small quantity of radioactive phosphorus had been added so that it could be traced. The six bees also collected this. Four hours afterwards one-fifth of a large sample of bees from the colony had received a share. A day later one-half of the bees had obtained a share of the tablespoonful of syrup, and two days later all the older larvae had received a little. It had been distributed through the colony. (Radio-carbon would be an even more convenient tracer than radio-phosphorus, and Mr. Ribbands plans to use it in future researches.)

This food-sharing is the basis for coordinating the activities of all the individuals, said Mr. Ribbands.

He then described another set of experiments, which were concerned with mutual recognition. Two dishes of syrup were placed on the ground about a yard apart, and a group of marked bees from one colony were trained to forage from one dish while a group from another colony went to the other. Both groups attracted recruits, and most of the recruits went to the dish which was being visited by the bees of their own colony. The recruits did not recognise their comrades by sight or sound but by their odour. In consequence of the food-sharing, all the foragers of a colony obtain a similar diet, from which they produce similar odorous waste products, which are emitted from their scent gland and which their companions can recognise and can distinguish from the odour emitted by honey bees from other colonies. Honey bees can distinguish the distinctive odour of their comrades from the odours of intruders; this helps them to defend their colony.

Food-sharing is the basis of the allocation of duties in the colony and of recognition among its members. It is therefore their most primitive and their most important means of communication, indispensable to the organisation of their complex social life. (Full results from these experiments have just been published in the *Proceedings of the Royal Society*, B, Vol. 140.)

How Synthetic Fibres have Revolutionised the Textile Industry

THE revolution in the textile industry which has followed the introduction of synthetic fibres was discussed by Dr. D. W. HILL, Deputy Director of the British Cotton Industry Research Association, in a paper to the Chemistry Section. The rapidity of the change was brought home by his remark that "The same basic materials were used by milliners in the fashion houses of Paris at the beginning of the twentieth century as had been used thousands of years earlier by the dressmakers in the courts of the Pharaohs—the introduction of viscose rayon changed all this." The world production of all textile fibres is about 20,000 million lb. Of this the rayons contribute 14%, and the true synthetic fibres about 1%.

Viscose rayon was an *empirical* discovery. After chemists and physicists had unravelled the intricacies of the molecular structure of certain synthetic polymers in which the atoms are arranged in long chains, it was possible to aim at the preparation of new synthetic fibres with specified properties. The first of these was nylon, which has since been followed by perlon, orlon, vinyon, terylene (discovered in 1940 by Whinfield and Dickson working in the research laboratories of the Calico Printers' Association, and now being actively developed by Imperial Chemical Industries). Modern theory has taught us how to modify fibres to meet more exactly the demands made upon them, and Dr. Hill cited the example of nylon which was first used for stockings, but during the war was made into parachutes, glider tow-ropes and now bullet-proof vests. The introduction of rayon produced a social revolution comparable in its effects with the Industrial Revolution. It is not a wild guess that nylon, terylene and other synthetic fibres are destined to bring about another, concluded Dr. Hill.

The Effects of Hormones on the Skin

IN a paper to the Zoology Section, Prof. W. S. BULLOUGH expressed doubts about the efficiency of face creams containing hormones. Prof. Bullough began by explaining how recent researches have indicated that energy is of vital importance to the process of replacement of the skin cells; this leads one to the fact that skin replacement takes place mainly during sleep when energy is not being used up for other purposes.

A number of hormones also affect energy production, and so influence the rate of renewal of the skin. Curiously the so-called pituitary growth hormone inhibits energy production and so inhibits growth. The substance is evidently misnamed, and the stimulus which it can give to growth is perhaps caused by the induced secretion of other hormones. One of these may be insulin, which is certainly capable of stimulating cell replacement in the skin by assisting the uptake of glucose from the blood.

The female, or oestrogenic, hormones also strongly stimulate skin growth, apparently because, like insulin, they help the tissues to absorb glucose. For

this reason they have been incorporated in some face creams. However, their value to the complexion is very doubtful because their action is so short-lived. With continuous oestrogen treatment, a reaction quickly sets in. This is apparently due to some stimulus to the adrenal cortex, which then actively secretes hormones similar to the now famous cortisone. These adrenal hormones depress the rate of energy production and have a powerful inhibiting action on skin replacement. Indeed they suppress growth in general.

Incidentally, this mechanism of growth suppression which is brought into play by the female, or oestrogenic, hormones probably accounts for the smaller size of most female mammals. The male, or androgenic, hormones do not appear to cause any extra secretion of cortisone-like hormones so that the growth of a male mammal is not suppressed.

Antibiotics in Chicken Food

THE increase in the growth-rate of chickens and pigs which follows the addition of an antibiotic such as aureomycin to their diet was a recent discovery, and one that surprised nutrition experts. Many experiments have been put in hand to get information about the way in which the antibiotic affects growth-rate in these circumstances. One research establishment working on the problem is the National Institute for Research in Dairying, Shinfield (near Reading), and the results of experiments carried out there with chickens suggest that the effect is due to the presence in the chicken's gut of an unknown organism which keeps the growth-rate down until penicillin is added to the diet; then the organism's mildly pathogenic activity is suppressed and the chicken grows more rapidly. Dr. M. E. COATES, of the dairying research station just mentioned, gave a paper about his researches in this field.

He said that three hypotheses have been proposed to account for the growth-stimulating properties of antibiotics:

(*a*) Antibiotics may themselves be essential growth factors.
(*b*) Oral administration of antibiotics may alter the intestinal micro-organisms to the benefit of the host.
(*c*) Antibiotics may suppress infection which interferes with normal growth.

The first, Dr. Coates said, is unlikely since a number of antibiotics of different chemical constitution all have a similar growth effect; in addition, this effect is shared by sulphonamides and some detergents and is, therefore, more likely to be brought about through their common antibacterial action. The other two hypotheses have been investigated at the National Institute for Research in Dairying.

These experiments have been done with chicks given a diet containing 25 milligrams of penicillin (procaine penicillin) per kilogram of feeding-stuff. Assays have shown that the penicillin survives in concentrations high enough to suppress bacterial action as far as the lower intestine, but no consistent bacteriological differences have been detected between birds with or without the antibiotic, either by direct microscopy or by cultural methods.

Changes in the population of microbes in the chicken's gut are likely to result in changes in vitamin requirements of the animal; this particularly applies to those vitamins of the B complex that can be synthesised by micro-organisms present in the intestine. Dr. Coates said that his experiments with diets deficient in any one vitamin have indicated that penicillin increases the chick's requirement for nicotinic acid, but spares biotin, folic acid and one or more unidentified components of the animal protein factor complex. These vitamin economies alone are insufficient to account for the dramatic growth response to antibiotics, particularly as significant growth increases can still be obtained even with diets containing ample vitamins and animal protein.

Dr. Coates said that comparison of his results with those of workers at Glaxo Laboratories Ltd. showed a difference, in that chicks at Glaxo receiving good rations did not respond to penicillin and grew as well without it as his birds on the same ration plus the antibiotic. "Our own animal room had been in continuous use for chicks for at least ten years, whereas poultry had rarely been housed in the Glaxo laboratory," explained Dr. Coates. "Repetition of the experiment on our own premises showed that birds in an environment hitherto unused for poultry also grew better than chicks in the old room and their growth could not be improved by penicillin. The antibiotic was, in fact, preventing a depression rather than causing an increase in growth. Chicks in the new room receiving no antibiotic showed a similar weight depression when birds from the old room were placed in the same cages with them." Careful examination of the birds revealed no sign of any recognisable disease, but Dr. Coates suggested that the improved growth when antibiotics were fed in the old room resulted from suppression of an infectious condition that prevented the birds from growing perfectly. No sign of the 'infection' other than a slight growth depression has been observed. The Shinfield research team is now trying to discover the nature of the organism or organisms responsible for the effect.

The Progress of Aeronautics

AERONAUTICAL science and engineering received considerable attention at this year's B.A. meeting; for instance, there was one joint session for the engineers and physiologists devoted to the "Biology of Flying", while Sir Ben Lockspeiser's presidential address to the Engineering Section dealt with progress in aeronautical science and technology.

Sir BEN LOCKSPEISER, who was in charge of aeronautical research at the Ministry of Supply before he became Secretary of the D.S.I.R., began by saying that nothing so surely puts a stamp on an era as the means of communication, travel and transport. Now air power was decisive in war; in peace the trend is indicated by the striking growth of air traffic—for instance, in 1951 nearly a third of all the people who crossed the North Atlantic went by air.

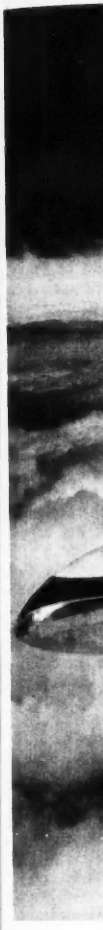
He paid particular tribute to the pioneer work of the Wright Brothers (whose flight at Kitty Hawk was made in 1903, a year after the British Association last met in Belfast), and emphasised the scientific nature of their approach. He reminded the audience that the wind-tunnel from which they derived data essential to the design of their machine was their own invention. "They studied the difficult problem of stability, particularly that of lateral stability, and it was their mastery of this problem, and the type of control they invented, which enabled them to overcome side-slipping and to avoid the tragic fate which overtook earlier experimenters. The epoch-making achievement of the Wright Brothers was in fact the outcome of a rare combination of science, invention and engineering."

The three aeroplanes which established the first stage of the Air Age were those of the Wrights, Bleriot, and Alcock and Brown. Since then the aeroplane had evolved from a wooden skeleton, covered in fabric, to a streamlined, all-metal monoplane built up of hollow shells in aluminium alloys. A glance at the most modern and cleanest of our aircraft, the Comet, in flight shows the magnitude of the change.

Another example showing what rapid progress aeronautical science has made is provided by the achievement of supersonic flight. Sir Ben told how, in a relatively short span of years, the view that the 'sound barrier' constituted an *impassable barrier* for aircraft was rendered obsolete by practice. Big difficulties had to be overcome before supersonic speed was achieved, but they turned out to be less formidable than was originally anticipated. He credited the Americans with discovering much of the information vital to the production of supersonic aircraft. (The Americans, he said, obtained their scientific data largely from rocket-propelled models experimented on by the National Advisory Committee on Aeronautics. This data was made available to Britain.)

Sir Ben spoke of the relative efficiencies of the different kinds of aircraft propulsion. Up to 400 m.p.h. the *propeller engine* is very efficient, but at higher speeds 'compressibility drag' reduces the efficiency sharply.

On the other hand, with *jet engines*, the propulsive efficiency increases with the speed of the aircraft. The turbo-jet engine is much lighter and occupies less space than a corresponding piston engine and propeller, offset though this is by the jet engine's higher specific fuel consumption.



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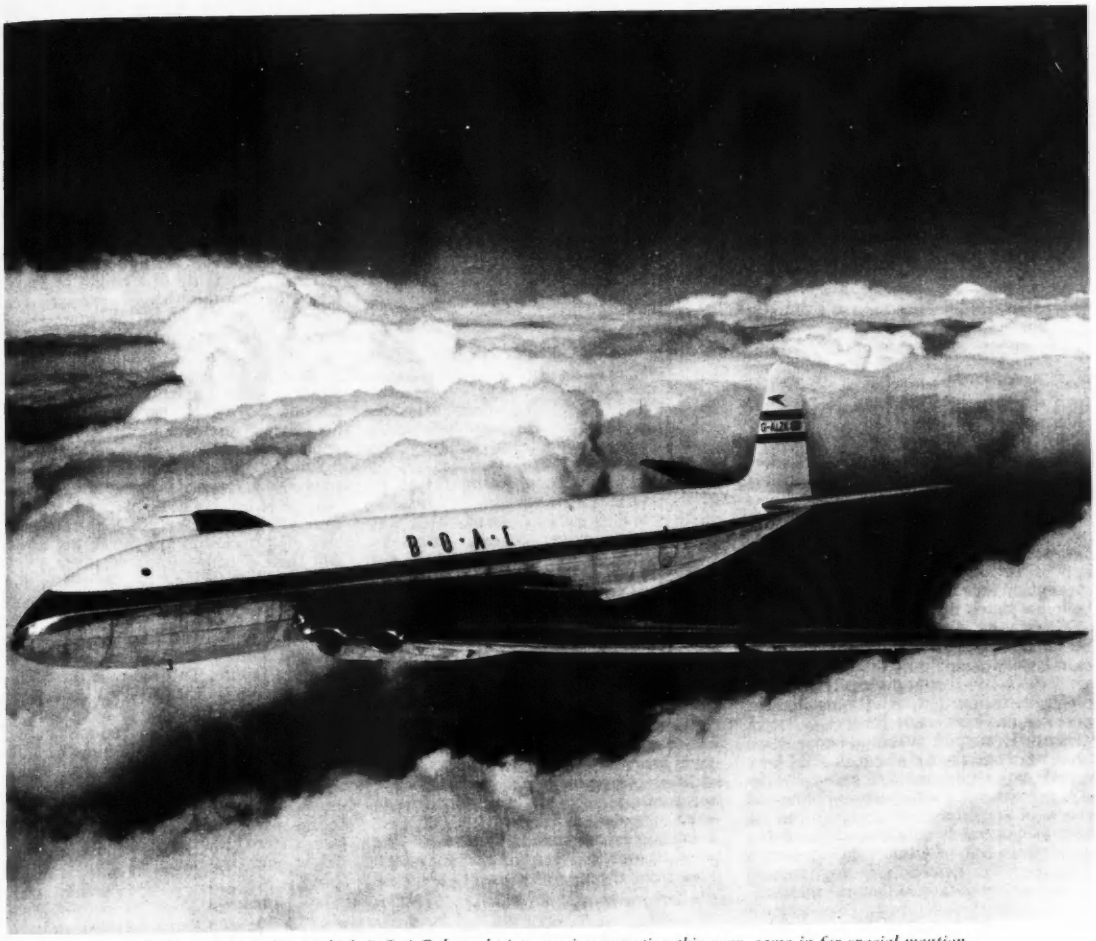


The Comet jet airliner, which B.O.A.C. brought into routine operation this year, came in for special mention in the lecture of Sir Ben Lockspeiser, who described it as "the most modern and cleanest" of British aircraft.

"We pay for speed by fuel consumption. A fast aircraft at the beginning of a 2000-mile flight is virtually a flying tanker. The all-up weight of the Comet fully laden is about 47 tons of which 46% is fuel."

The *rocket motor*, in which the oxygen for combustion is drawn not from the surrounding atmosphere but is self-contained within the fuel, has the following main advantages:

(i) Its simplicity and cheapness.

(ii) The high thrust per unit area of combustion chamber cross-section (e.g. 10,000–30,000 lb. per sq. ft.).

(iii) Maintenance of more or less constant thrust with altitude. (This is peculiar to the rocket motor, and is particularly important in obtaining high rates of climb at high altitudes.)

Its fuel consumption is very high; 15–20 lb. of fuel is consumed per hour per pound of thrust, as against 1–3 lb. for the various kinds of jet propulsion systems.

Referring to metallurgical developments upon which aeronautical progress is so dependent, Sir Ben Lockspeiser singled out for special mention the newer magnesium alloys—especially those containing *zinc* and *zirconium*, which have proved of great value in lightweight castings such as those for the compressor casings of aircraft gas-turbines, being considerably stronger than the best aluminium alloys.

Sir Ben described a new and simple method for landing and launching fighter planes which is being tested experimentally. The idea is to get away from the need for long runways which limits the operational use of very fast fighter planes. The plane is launched by a catapult and does a 'belly landing' on a tautly suspended flexible sheet. "The aeroplane is flown level a few feet from the ground, is caught on a hook by an arrester gear and dropped on the sheet, which allows a good landing without bounce," Sir Ben said. "Many landings of a Vampire jet plane have been made successfully by this method." Eliminating the undercarriage increases the speed and range of the fighter by reducing its weight. The system would also enable fighters to be based near front lines without the need for building air-strips.

Sir Ben stressed the expensiveness of modern airfields. He cited London Airport, which covers nearly 3000 acres and has concrete runways etc. which are equivalent in bulk to a concrete motor road 20 ft. 8 in. wide covering a distance equal to that separating London and Edinburgh. Its cost to date is £10 million, and this will be doubled when the airport is complete. "If aircraft are to become faster and heavier the main economic problems in aeronautics are, in my view, less on the air than on the ground. The future in the air may well lie in the conquest of the ground." Sir Ben pointed to the great potentialities of flying-boats and helicopters, the development of which can get round this kind of limitation.

The Biology of Flying

ONE complete session was given up to a joint meeting between the engineering and physiology sections which examined some of the biological problems connected with people—civilians as well as airmen—who fly in modern aircraft.

Dr. K. G. BERGIN, Medical Superintendent of London Airport, outlined some of the physiological problems. He said that now some 228,000 passengers fly across the Atlantic every year—more than the passengers carried on all sea passages. This fact makes the spread of infection a serious possibility. The five main diseases to be controlled are smallpox, yellow fever, plague, typhus and cholera. Immunisation is useful here in connexion with these diseases, and is most effective with the first two. Air travel makes necessary an elaborate system of recording and form-filling so that there is a check on everyone who is a potential spreader of infection; nobody, not even the pilot, is exempt from this procedure in which international co-operation is essential. Strict sanitary measures are enforced in aerodromes in disease-infected areas, and insecticides are applied to any aircraft coming from or through an area in which there is known to be insect-borne disease.

The health of aircrews is closely watched. There are regular medical checks on each man and woman, and there is constant supervision of flying duties. Fatigue is especially important, and only limited progress has been made here. Dr. Bergin illustrated this part of his paper with an account of one airman who had asked for a private talk with him. This pilot was unable to say what was the matter but he was aware of something being wrong, and he had, in fact, made a serious error in flying only four days earlier. Dr. Bergin diagnosed the trouble as being nothing more than acute fatigue, and the pilot was taken off flying for a month; he returned to duty a different person. Another trouble with pilots is progressive deafness. This is caused by the constant subjection to noise, and because of the pilot's position on the left-hand side of the cabin the left ear is somewhat more affected than the right ear. This deafness takes the form of loss of high-frequency sensitivity. One hour of flying is enough to reduce the sensitivity above 2000 cycles per second by forty decibels. A test-pilot working for two years has actually lost sensitivity to the extent of up to ninety decibels in the higher frequencies. The remedy is protection of the ears, not always a comfortable thing to do in tropical climates, and a remedy about which a pilot tends to be careless.

THE ADVANTAGE OF BACKWARD-FACING SEATS

Other physiological problems arise in connexion with acceleration and retardation. A crash-landing subjects the body of anyone in an aircraft to great stresses. If a person is seated facing forwards he is, in a crash-landing, subjected to a forward force. This is expressed in a multiple of g, the acceleration due to gravity. (An extra force of, say, 20g is equivalent to a force twenty times the weight of the person.) Experiments have shown that the physiological limit in a fit young man is a forward force of 25g, an upward force of 20g, or a downward force of 10g. If the force is backwards there is no limit. Backward-facing seats are therefore advantageous in connexion with this problem of crash-landing. (A later speaker, Mr. Rendel, stated that the majority of deaths in crash-landings have been caused by the forward force, which has thrown the passengers forward to hit their heads on the seat in front.)

Flight at high altitudes brings with it problems caused by lack of oxygen. Modern high-altitude aircraft are 'pressurised' at a convenient air pressure inside, and so no problem of oxygen-lack arises unless there is a structural failure in the pressurisation. Oxygen-lack causes a deterioration in judgment and loss of discrimination, then a feeling of irresponsibility, and eventually death. This was considered in more technical detail by Group Captain W. K. STEWART of the R.A.F. Institute of Aviation Medicine. At a height of 10,000 feet (without pressurisation) the saturation of arterial blood never rises higher than 89% of the maximum, and this lack of oxygen in the body produces fatigue. So flight without additional oxygen should never expose crews to cabin altitudes greater than 8000 feet—the figure usually now taken as the height whose equivalent barometric pressure is used for the pressurisation. Even the addition of pure oxygen does not prevent unconsciousness at altitudes greater than 40,000 feet. At a height of 52,000 feet, following decompression (failure of the pressurisation suddenly or ejection of the pilot from the aircraft), unconsciousness comes in ten to fifteen seconds. If the engineer cannot guarantee the integrity of the pressurised aircraft at this height—the integrity must be greater than that of a submarine—he must either provide a means of escape from the aircraft (and the escape mechanism must come into operation within the few remaining seconds of consciousness) or an artificial atmosphere around the pilot.

Mr. DAVID RENDEL of the R.A.F. at Farnborough dealt with some of these problems from the point of view of the engineer. He showed that control of the atmosphere inside an aircraft cabin was relatively simple up to a height of 25,000 feet, for at this height pressurisation demands only double the atmospheric pressure and does not involve control of the humidity, and at the same time life can be sustained at this height for a long time. At much greater heights, however, and for aircraft moving at very high speeds, the problems of pressurisation increase. This applies primarily to military aircraft.

A man escaping from an aeroplane is subjected to reduced pressure and temperature; after leaving it, he proceeds to move through the air at a speed high enough to tear off his clothes and break his bones, and then is called upon to make a safe descent by parachute. At speeds greater than 180 miles an hour it is not even possible for a man to climb out of the aircraft. The initial opening loads on a parachute at a height more than 20,000 feet are enough to cause failure. To overcome these difficulties an ejection seat is used, so that the man in the remaining few seconds of consciousness can release the mechanism, be shot out of the aircraft complete with personal oxygen equipment and attached to a parachute that opens automatically only at a pre-arranged barometric pressure. In this way the engineer has made possible escape from a damaged aircraft at a great height and travelling at an enormous speed.

The Shape of Wings to Come

AIRCRAFT designers, as a class, fix their eyes on the future, and their concern is with designing planes which will take the air five or ten years from now. By the time their new projects have reached the prototype stage and are ready for exhibition at air displays, such as that held each year at Farnborough, the designs have lost their novelty for the designers, however futuristic and revolutionary they may seem to the public receiving its first glimpse of a new machine.

Tailless aircraft for example, are still generally looked upon as very advanced and as representing a complete break with the past. To Mr. KEITH-LUCAS, who presented a paper to the Engineering Section entitled "The Shape of Wings to Come", and who is chief designer of Short Bros. and Harland (the Belfast aircraft firm), they represent something quite different from that. He said that a tailless aircraft is no unnatural freak, even though it appears to be so to people used to thinking in terms of ordinary aircraft with the conventional arrangement of a long, slender fuselage and a tail. Mr. Keith-Lucas continued, "If we observe nature carefully we notice that seagulls and ducks and many other birds are, in effect, tailless at least in straight flight, and bats are tailless at all times and are probably the most manœuvrable of all fliers. Gulls use their tails in manœuvring but, as far as one can see, more as air brakes than as elevators and, incidentally, they use their feet in the same way. There is a strong argument for a tailless design on structural grounds. In a pull-out from a dive or in a high-speed turn there is a large up-load on the wing and usually a down-load on the tail. On a conventional tailed aircraft with swept-back wings the moments due to these loads cancel each other out only through the long path up the fuselage and the wing to the centre section. With a tailless design, on the other hand, the down-load of the tail occurs at the wing-tips and so we not

only avoid the need for a structurally strong and stiff fuselage but reduce the bending moments in the wings also. There is, therefore, a potential gain in structure weight as well as in drag, which must be offset against the fact that the tailplane, if we may call it that, has a shorter moment arm and therefore has to be larger."

He made it clear that he considered the case for the all-wing tailless aircraft—such as the Avro 707 with a delta wing—was now firmly established. This type of design now rivals the 'Big Stick' design of such planes as the Boeing B47, which has swept-back wings, a long fuselage and a tail.

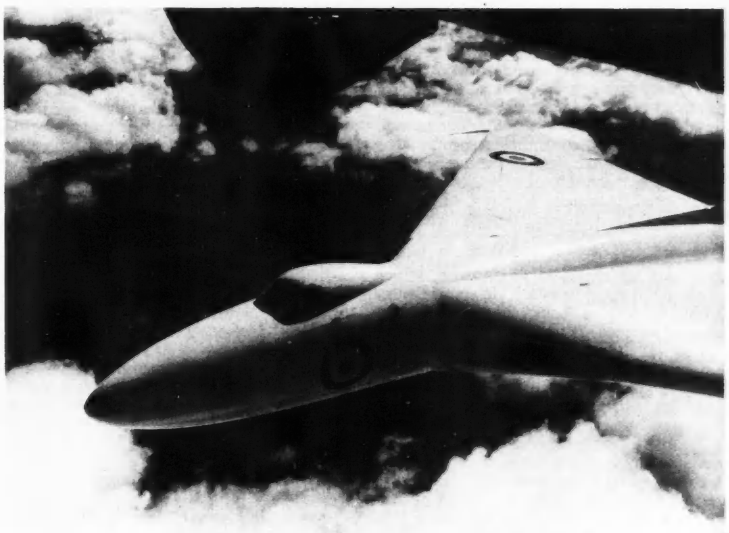
Mr. Keith-Lucas showed his audience designs for more revolutionary planes such as are in the early design stage in which a wing arrangement that is strongly reminiscent of birds such as gannets is the most outstanding feature. (Two of these designs are reproduced on this page.)

ATOMIC POWER FOR AIRCRAFT

The speaker also had something to say about the prospect of atomic-powered aircraft, though he said that British aircraft designers were at a disadvantage compared with their American counterparts in that they had difficulty in obtaining data about projected atomic-power units from the Government department concerned with atomic research and development.

Said Mr. Keith-Lucas, "It is very tempting to plunge into speculation as to the shape of these future craft, but it is doubtful whether there is any value in doing so until our knowledge is on firm enough foundations to support the structure of a logical argument. The atomic-powered air liner might be a possibility today but it would have to be extremely large and would probably be uneconomical on account of the enormous weight of the screening necessary round the reactor unit. We could argue from that single premise that the aircraft ought to be a flying-boat because of the high landing weight which, on a landplane, would mean a heavy undercarriage and the need for airfields with exceptionally long runways capable of taking very heavy loads. All of this is an expense which the taxpayer would be glad to dodge. The reactor unit and engine would be in the hull of the boat and the passengers would have to be housed in the wing or in the wing-tip floats.

"We could now prepare a sketch of the atomic-powered flying-boat but it would not be altogether convincing because it would strike us as old-fashioned. We have indeed been applying the old arts of aircraft design to a new form of propulsion, whereas a much more radical approach is needed. The jet fighters of today are not the Spitfires or Hurricanes of yesterday with new engines in them but are of new shapes to suit the new conditions. What shape the atomic-powered aircraft will be is a subject deserving much thought when we know enough about the characteristics of the engine. Will the engine really weigh so much or shall we again find that what we thought was fundamental is no more than a passing phase? Somehow it seems unlikely that the atomic-powered aircraft will look old-fashioned. It will come as a challenge and a stimulus to new research in structures and aerodynamics, but this time Britain must lead and not wait to pick up the threads from a narrowly defeated enemy. There must, therefore, be a close understanding between the atomic research establishments and the aircraft industry. Unnecessary secrecy will deprive the country of the chance to lead in the atomic age."



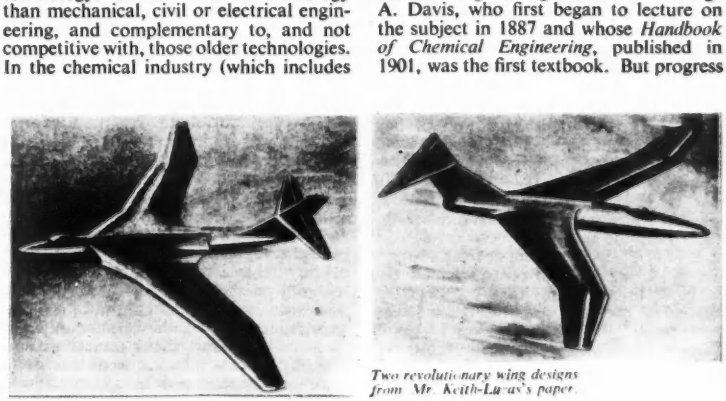
A tailless delta-wing aircraft—the Avro 698.

The Importance of Chemical Engineers

THE importance of chemical engineers and how these technologists should be trained were topics discussed at a meeting of the Engineering Section.

Sir HAROLD HARTLEY described chemical engineering as the fourth primary technology. It was a newer technology than mechanical, civil or electrical engineering, and complementary to, and not competitive with, those older technologies. In the chemical industry (which includes the oil and gas industries) the chemical engineer is the co-ordinator of the other three kinds of technologists. Sir Harold said that Britain trains too few chemical engineers; 5000 new chemical engineers become available to American industry every year whereas Britain's output is only about 200 a year. He described the subject of 'Chemical Technology', which is still taught in some British colleges, as obsolete. Said Sir Harold, "It tends to produce too specialised experts who have a rather limited outlook. The subject may have a place in technical colleges but it is foreign to a university. It produces technologists who lack *adaptability*, which is the outstanding feature of the chemical engineer."

Dr. D. M. NEWITT, Professor of Chemical Engineering at the Imperial College of Science and Technology, reminded his listeners that one of the great pioneers of chemical engineering was British—George A. Davis, who first began to lecture on the subject in 1887 and whose *Handbook of Chemical Engineering*, published in 1901, was the first textbook. But progress



Two revolutionary wing designs from Mr. Keith-Lucas's paper.

in Britain was slow, and it was left to Germany and America to build up those renowned schools of chemical technology and chemical engineering which, during the years between 1918 and 1939, gave them so great a lead in the world race for industrial productivity. "We now have to face the task of recapturing some of the lost ground and, by increasing our facilities for higher technological education and vocational (technical) training, of making available to industry the skilled men required at all levels for the purpose."

Prof. Newitt described the type of graduate in chemical engineering which we need in these words: "He should enter industry with a background of fundamental science, with some knowledge of industrial organisation and with a sound understanding of the basic operations of chemical engineering. He will not be familiar with the practice of any one industry nor with those technical details of plant operation which can only be acquired by works experience; and it must be recognised that some time will elapse before he can be expected to make his full contribution as a technical specialist. He should, however, be competent at the outset to undertake design and development work and to bring to it those qualities of initiative, originality and adaptability which are so urgently needed in industry today."

Dr. E. H. T. HOBLYN, who is secretary of the British Chemical Plant Manufacturers' Association, stressed the great value of graduate chemical engineers in industry and also the contribution to be made by chemical engineers trained by shorter courses to Higher National Certificate level. He said, "The most significant advance which has been made recently in the scope of chemical engineering training is the establishment of Higher National Certificates in the subject; the courses to the H.N.C. will be taken by students holding a National Certificate in chemistry or engineering. Industry should welcome these new courses which will produce what have already been described as the N.C.O.s of the chemical and chemical-plant industries. It is for industry to ensure that sufficient raw material is forthcoming from its ranks to warrant the establishment of H.N.C. courses in various centres. It must also ensure that it uses these N.C.O.s properly: first, they should be employed at a level of work suited to their training—in some cases this should enable better qualified men to be released for more responsible duties, while in others it should enable more chemical engineers to be used on duties for which at present they are sadly lacking, such as plant and process control as mentioned earlier. Secondly, industry must provide the N.C.O. with the incentive of promotion, where competent, to commissioned rank. Care must be taken by those concerned that H.N.C. chemical engineering courses are not established in centres which are so close together that they compete for students. It is far better to have fewer courses and that those courses be good and supported by properly equipped laboratories."

Dr. Hoblyn spoke of the help industry must give to chemical engineering students while they are still at the university by providing facilities for vacation courses. "There is, understandably, a school of thought which prefers the student to do something totally different during his long vacation, but most students prefer to obtain practical experience at some time during this period. Many firms now have excellent vacation training schemes from which the student can gain real benefit. It is imperative that firms accepting students for vacation work should do so with a full sense of their responsibility in assisting in their training, and that close liaison is maintained between the firms and the students' professor. Examples of the type of work on which students can be employed are operational tests on plant or the carrying out of pilot-scale work in connexion with some research problem.

"There is also good reason to devote one vacation to working on the shop floor. This does not mean that the student should spend hours learning to file flat or to operate some machine tool. He can, however, work on the assembly of plant in the shops, learning from this, good and bad features of design; he can gain some knowledge of the foundry and its problems by working as a mate to a good moulder; physical operation of a plant which does not readily lend itself to modern methods of automatic control will provide an experience the value of which cannot be lost. There is also a vitally important human aspect of this type of vacation work—it brings the student right alongside the workman; he learns something of his outlook on life, how he thinks, how he works out problems, and above all he learns how to get on with him. Many first-class technical men have failed in plant work because they possessed the unhappy knack of upsetting workpeople."

The Assessment of Personality

A LECTURE calculated to promote critical re-examination of methods of assessing personality was delivered by the president of the Psychology Section, Prof. P. E. VERNON, of the Institute of Education, London. His address, called "The Assessment of Personality", foreshadows the publication of Prof. Vernon's book with the same title which is in the press and will appear next year.

Prof. Vernon defined the term 'personality', explaining that he used it to connote the whole of a person's outstanding characteristics, emotional and social traits, interests and attitudes, distinguishing him from other personalities.

Speaking from his twenty-five years of experience in this field, Prof. Vernon said psychologists could not claim to have made much progress in the practical task of assessing personality simply and accurately: "We fully realise the importance of taking personality factors into account in guiding or selecting children and adults into suitable educational or vocational careers. But we are certainly not in a position to provide the teacher, the Youth Employment Officer or the personnel official with a straightforward battery of personality tests comparable to our tests of aptitudes and attainments."

Nevertheless, there had been considerable advances, said Prof. Vernon, especially in experimental work into problems of personality. Psychologists now possess the *tools* for investigating such things as the origins of anti-Semitic and other prejudices, the influence on children's personalities of education in progressive schools as contrast with formal schools, and the effect on their development of different kinds of home atmosphere or of treatment during infancy. The research methods of investigating these problems had not added much to our knowledge of personality psychology, but they did provide information as to the adequacy (or inadequacy) of the tests commonly used in personality assessment.

Prof. Vernon brought home the need for improving methods of personality assessment by this example. Two grammar-school headmasters interviewing a hundred 11-year-old candidates in order to pick out the best twenty for grammar-school education would agree with regard to only half of the twenty; that is, ten boys would figure in both lists of chosen pupils, but the lists would differ in respect of the remaining ten pupils. (The index measuring the extent of their agreement—the *correlation coefficient*—is 0·5 in this instance. Figures up to 0·8 can be achieved with trained interviewers who have analysed beforehand just exactly what qualities they are looking for in the interviewees.)

Prof. Vernon spoke favourably of the selection methods used by Britain's Civil Service Boards in connexion with appointments to the Administrative Grade and the Foreign Service. These take into account academic examination results, past record and testimonials, and several intelligence and other tests are given. Improved results were obtained when 'group exercises' were included in the tests; in these, groups of eight candidates are observed while carrying out activities analogous to those of civil servants—e.g. discussing some controversial problem, summarising and expounding a brief, taking the chair at a committee. Also included in the Civil Service System is the interview by the Selection Board's chairman and by a trained vocational psychologist.

Prof. Vernon summed up the results of Civil Service selection methods in these words: "Tests and examinations have very poor predictive value, but with accumulation of evidence from the group exercises, the validities rise. The interviews seem to add very little, but actually the judgments from exercises may to some extent be helped by interview data."

The value of interviews by skilled interviewers is also attested, he said, by the success of the vocational guidance given by the National Institute of Industrial

Psychology. Here each candidate takes a few intelligence and aptitude tests, and school records are consulted, but recommendations regarding suitable types of job are based chiefly on an interview by a psychologist, which systematically covers the candidate's life-history, interests and other relevant qualities. It is regularly found that, of candidates who follow the psychologist's advice, over 90% are satisfied with, and satisfactory in, their jobs several years later, whereas among those who do not follow it only some 50% are equally successful.

With regard to the relative values of subjective and objective methods of personality assessment, Prof. Vernon said this:

"The clinical psychologist or psychiatrist is more aware than the layman both of the complexities of personality structure and of the need for caution and suspended judgment in interpreting the personalities he is attempting to diagnose. But he is deluding himself if he thinks that the full case-study which he produces after intensive observation and interview is necessarily more objective than the unsophisticated layman's picture. Often he is more ridden by preconceived stereotypes and theories, and the deeper he penetrates the more he may fail to see the wood for the trees, the more biased he may become. Some psychologists, therefore, such as Dr. H. J. Eysenck [author of *The Scientific Study of Personality*, 1952], conclude that this clinical or 'idiographic' approach should give way to the psychometric or 'nomothetic' approach based on objective personality tests. But this, too, has serious weaknesses. We have seen that behaviour which is symptomatic of personality varies greatly with the situation, and an important part of the situation is the attitude of the subject being tested. Thus we find that tests which work well with one group of subjects often fail to do so with another group which is differently motivated, or which is suspicious of the tester. The psychologist's tests, it should be realised, are not miraculous instruments for revealing things which could not be discovered by any other means. They are merely samples of behaviour obtained under specified conditions. It is essential, therefore, to include a wide variety of behaviour samples in any attempt to assess personality or measure personality traits, to discard the samples which are too trivial or too unrepresentative, and to combine only those which can be proved valid. This can be, but it is not easy, and, as I have already indicated, it is scarcely possible in everyday guidance and selection, as distinct from experimental investigations. Nevertheless, such work has been carried to the stage where we do possess a number of useful and relatively objective methods which could be given with a view to supplementing, checking and correcting the vagaries of more subjective methods like the interview.

Prof. Vernon made it clear that two commonly used tests—the Rorschach inkblots, and the Thematic Apperception pictures which have been used in War Office and Civil Service selection—do not contribute any worthwhile information. Both tests help in diagnosis of abnormal personalities, but they have failed to prove their worth in educational and vocational selection and guidance.

He also criticised the personality ratings used in Britain's primary schools. "Largely at the behest of psychologists, most Education Authorities nowadays get primary schools to include personality ratings on their pupil record cards, and these are often consulted at the 11-year selection stage, or passed on to the secondary schools to guide the future teachers. I am afraid I have entirely lost faith in such ratings. Even if the primary teachers could be trained to attach a uniform meaning to the traits that are listed, and to judge from objective observation rather than from general impression, there would still be so much variation in standards between raters in different schools that it is almost impossible to interpret the assessments."

Transfer of Training: more Realistic Experiments Needed

"TRANSFER of training" is a term used by psychologists when they are discussing the degree to which training in one activity confers skill which carries over to a separate and different activity. The subject of transfer of training is extremely controversial, and D. C. FRASER, of the Psychological Laboratory, Cambridge University, called for more experimental work to settle disputed points and expressed the view that experiments in this field should be designed to utilise *real-life skills*, rather than the kind of skills associated with unusual activities such as often figure in laboratory experiments.

Mr. Fraser stressed the importance in learning of transfer of training. The old idea, which was held by nineteenth-century educators, was the doctrine of formal discipline, according to which it is possible to train the mind by intellectual exercises comparable to physical exercises for developing muscles. If that theory is correct, then it would not matter much what subjects are taught to a child provided they give this intellectual exercise. But in its original form that concept of transfer of training is substantially untrue. The study of Latin, for example, will transfer to other subjects only in so far as the two are directly related—for example, only if there are similar sentence construction and similar roots. But in addition it may transfer *indirectly*, in that habits of concentration and resistance to boredom may carry over to other types of work—though this is not what the advocates of formal discipline meant by transfer of training.

Here a number of general principles have been established which have stood the test of time. Mr. Fraser said, "We may expect positive transfer to occur when there is *similarity of principles*, *similarity of content* or *similarity of technique* between two tasks. It is important that the similarity should be brought out as clearly as possible during the learning period. The more clearly we drive home the general applicability of a principle, the more effective the training will be. A famous example of this is Bagley's experiment on neatness. When the teacher in one school subject tried to encourage neatness in schoolchildren, there was considerable improvement in this particular subject, but no general improvement in other subjects. On the other hand, when neatness was held up as a generally desirable quality and its advantages were pointed out, there was an improvement in all school subjects."

Plants can Absorb Water from Fog

RECENTLY in America it was found that tomato plants growing in very moist atmospheres absorb water *through the leaves* to such an extent that the plants may start excreting water from their roots, which means a reversal of the normal direction of water-flow through a plant. If this phenomenon occurred in potato blight it might have a bearing on the spread of potato blight. This possibility is being explored by Prof. OLIVER ROBERTS of University College, Cork, who reported his preliminary findings to the Botany Section. He carried out his experiments by growing the plants in a large glass chamber in which an artificial fog could be created. He found that the potato plants do absorb water from the fog. Maximum infection of potatoes with the fungus that causes potato blight occurs when the plants' leaves are fully charged with water, but germination of the potato blight conidia can occur when the leaves have a moisture content of 4·5–15% below the maximum. Prof. Roberts said that water absorption by potato leaves from fog may conceivably increase their water content to an extent that increases the likelihood of infection with potato blight.

Peptic Ulcers: The Twentieth-Century Disease

THE fact that peptic ulcers are now very common is well known. But few people outside the medical profession are aware that they constitute a characteristic twentieth-century disease and that they were definitely uncommon before 1900.

This point emerged from a paper by Prof. G. F. W. ILLINGWORTH, professor of surgery at Glasgow University. He said that perforated peptic ulcers had become progressively more frequent since 1900. In the medical history of World War I the disease was barely mentioned, but in World War II it rivalled gunshot wounds as a cause of disablement. The increasing frequency, he said, may be due to increased psychological stresses or possibly to a dietetic factor.

In the early part of World War II there was a sudden increase in perforations coinciding with the London air raids, but this was a pure coincidence—a similar rise occurred in other unraided parts of the country, and in Sweden, unrelated to air raids.

Analysis of 8000 perforations shows a seasonal incidence. Perforations are least common in the late summer months and most common in December. They also vary in frequency on different days of the week, being commonest on Friday and Saturday.

The Bookshelf

The Alchemists. Founders of Modern Chemistry. By F. Sherwood Taylor. (London, Heinemann, 1951, 246 pp., 12*s.* 6*d.*)

IN the long history of chemistry, the part played by the alchemists is often misunderstood, the misunderstanding in our own time being possibly derived, first at long range, from the criticism that these early theorists drew upon themselves many centuries ago through the failure of their experiments to substantiate their theory and through the disrepute into which they fell through the exploitation of their ideas by rogues and charlatans, and secondly at short range, from the continued success of modern science since the sixteenth century in its attempt to unravel the mechanism of Nature and to apply the knowledge thus gained. Yet, while the reviewer would not be prepared to agree to the suggestion in the sub-title that the alchemists were the founders of modern chemistry, we cannot fail to recognise that it is to the alchemists that we owe the form and design of much of our chemical apparatus, especially the still.

This admirable book, written with scholarly understanding and sympathy, and written both for the scientific and the general reader, opens with an account of the theoretical origins of alchemy in the ancient Greek theories of *substance* and *form*, and *spirit* (*pneuma*), together with what information there is of the earliest alchemists, such as Mary the Jewess and Zosimos of Panopolis, the latter the first chemist to whom we can give a date (*c.* A.D. 300). Their apparatus, experiments and symbols are then described and admirably illustrated, with a most interesting representation of the probable course of evolution of the still, an item of alchemical apparatus of high theoretical significance, and historically notable since it was the alchemists, so far as we know, who first devised and subsequently elaborated the important chemical technique of distillation. Then follow chapters on alchemy in China, in Islam and in Europe, with another on alchemy in the fourteenth century and a most interesting one on the English alchemists, followed by another on the highly developed symbolism of alchemy in the later centuries of its practice in Western Europe. The concluding chapters deal with some of the famous claims of successful transmutation, the change in science from alchemy to chemistry, the survival of a non-scientific hermetic philosophy in an increasingly scientific age, and the relation of alchemy to science.

No better general account of alchemy than this is available; it is well illustrated and, as we expect from its author, well and clearly written. From it the alchemist emerges as a real human figure, with whose outlook we share something, since he was not the first honest student of Nature to be caught in the grip of a false theory, and to whose ingenuity we owe much of our chemical apparatus, since he largely devised and invented it.

This is the first English issue of the book; and librarians and bibliographers should note that it has already been published in America in 1949 and that the present issue is a replica of the American one.

D. MCKIE.

Co-operation Among Animals, with Human Implications. By W. C. Allee. (London, Sir Isaac Pitman & Sons, Ltd., 1952, 21*s.*)

THE title page states that this is a revised and amplified edition of *The Social Life of Animals* (1938). Nearly all the revision and amplification concerns the latter part of the book which discusses the human implications of the survey of social biology in the earlier part of the book. One whole new chapter has been added, and considerable alteration made.

The summary of our knowledge of social behaviour in animals is both clear and comprehensive, although it is a pity it has not also been brought more up to date. Excellent accounts are given of the biologist's approach to the study of animal behaviour and the beginnings of co-operation and learning amongst animals from the amoeba to the ants and apes, though his description and conclusions concerning the behaviour of ants are now somewhat out of date.

The comparison between his ideas about international co-operation in 1938 and 1952 is disappointing. The main thesis of his new chapter called "The peck order and international relations" is that practice in co-operation is a good idea: have an international organisation to look after the care of the children of the world, ensure adequate food production and distribution, and improve working conditions, especially among low income groups, and begin getting the habit of co-operation at simple, non-controversial levels. Meanwhile, Allee and his colleagues will continue working on their research into understanding more about the individual egoistical competition between animals and their conflicting co-operative urges and behaviour. Only one real conclusion is drawn from the actual biological research, and that is that if your population becomes too low, aggression between individuals is increased. At the same time it must not be too high or the food supply won't be adequate, which will also cause individual fighting. It is undoubtedly true that the study of social behaviour in animals can yield information of value in the study of human social behaviour, if only through the exchange of outlook and techniques suitably adapted, but Allee has certainly failed to make a good case for what is supposed to be the main thesis of his book. At the same time, the book is to be recommended to the general reader as one of the very few books which tells clearly how and, within limits, why scientists study animal behaviour.

DEREK WRAGGE MORLEY.

Night Sky in October

The Moon.—Full moon occurs on October 3d 12h 15m, U.T., and new moon on October 18d 22h 42m. The following conjunctions with the moon take place:

October			
6d 10h	Jupiter in conjunction with the moon	Jupiter	7° S.
20d 10h	Mercury ,,	Mercury	4° N.
21d 15h	Venus ,,	Venus	4° N.
24d 11h	Mars ,,	Mars	1° N.

The Planets.—Mercury is too close to the sun during the greater part of the month for favourable observation. Venus is an evening star, setting at 18h 25m, 18h, and 17h 50m on October 1, 15, and 31, respectively. Its stellar magnitude is −3·4 and the visible portion of the illuminated disk varies between 0·90 and 0·83. Mars is an evening star, setting at 20h 20m, 20h 10m, and 20h at the beginning, middle and end of the month, respectively, stellar magnitude 0·6 to 0·8. Jupiter rises in the early evening hours during October, at 19h 10m on October 1 and about an hour and two hours earlier on October 15 and 31, respectively. Its stellar magnitude is −2·4 and it is easily recognised a little south of δ Arietis. Saturn sets less than half an hour after the sun on October 1 and is in conjunction with the sun on October 11 when its times of rising and setting correspond closely with those of the sun, so that it will be unobservable.

On October 6 a number of stars in the constellation Taurus will be occulted by the moon. The first star in this constellation to be occulted is 17 Tauri at 21h 53·5m, and others will follow on at intervals until 23h 32m. Binoculars will show the stars approaching the limb of the moon—it would be more correct to say that the moon is approaching the stars because the occultations are due to the eastward motion of the moon as it revolves around the earth.

The Orionid Meteors—so called because they appear to emanate from a position lying towards the north of the constellation Orion—are active about October 18. It has been generally held that these meteors as well as another shower in the first week of May were due to the debris of Halley's Comet encountering the earth's atmosphere, but recent work by Prof. A. C. B. Lovell, at Jodrell Bank Experimental Station, utilising radio echo observations, has shown that neither of these showers can be associated with the debris of Halley's Comet.

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